

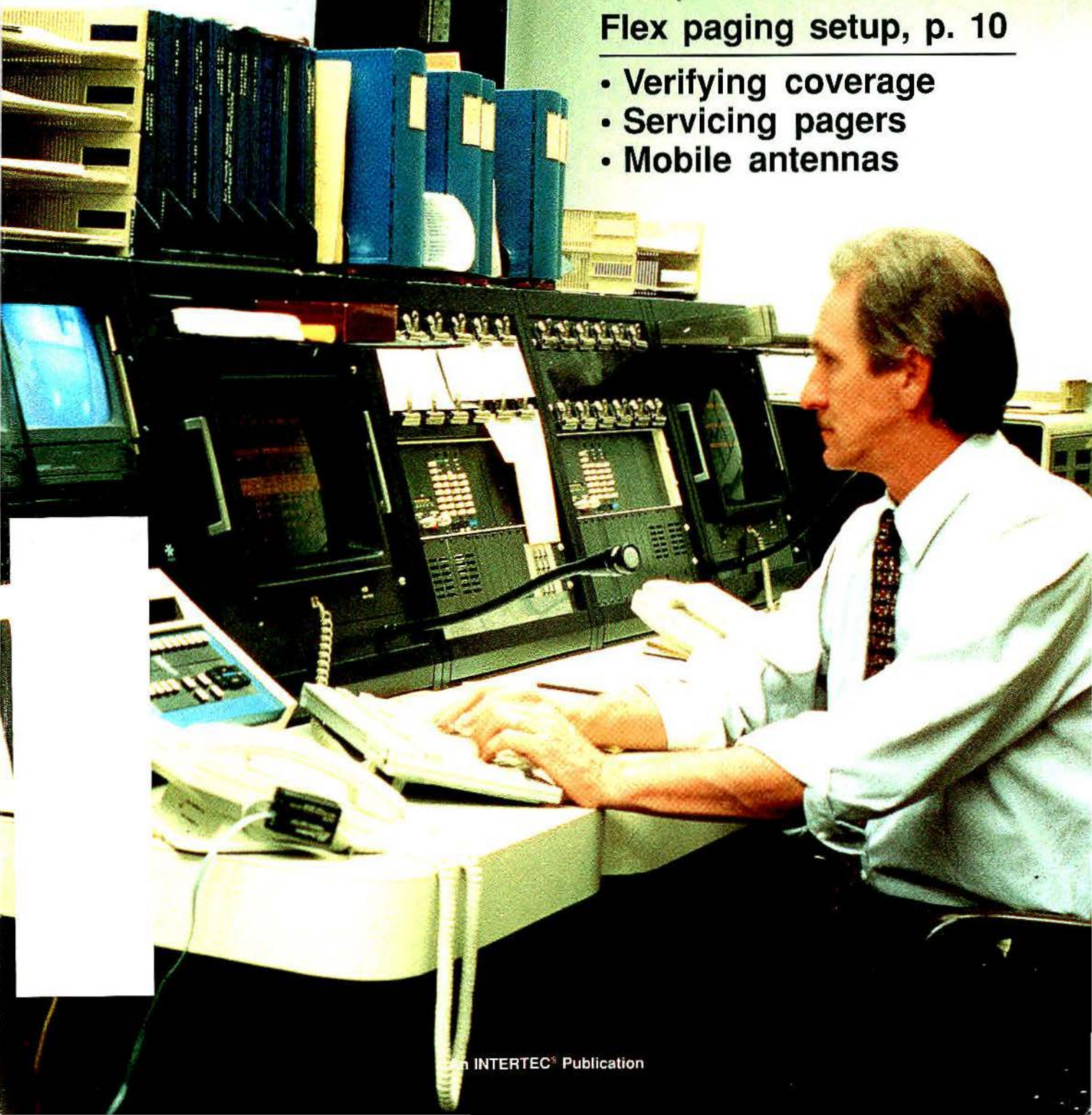
June 1995

Mobile Radio Technology™

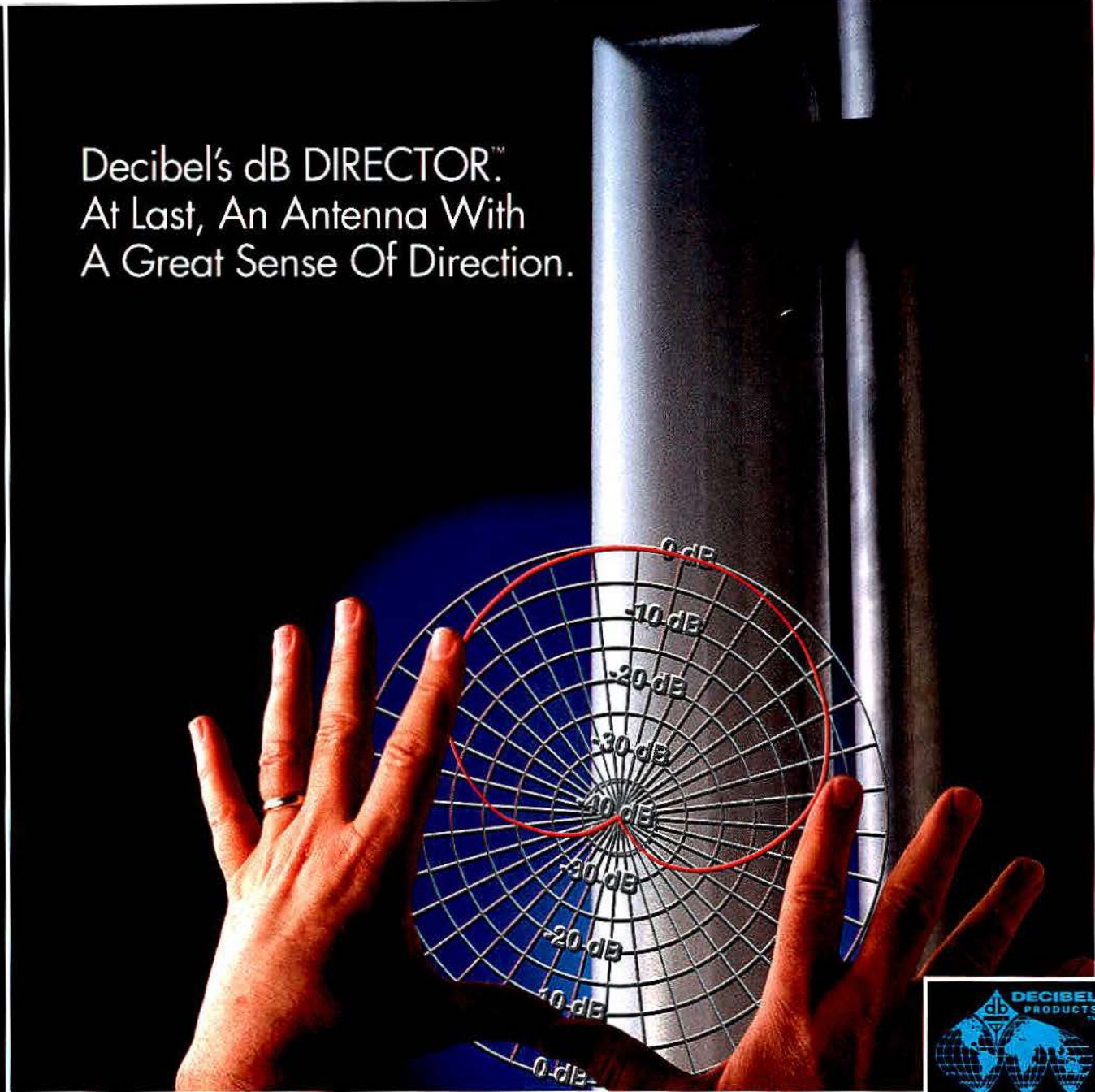
The journal of mobile communications technology

Flex paging setup, p. 10

- Verifying coverage
- Servicing pagers
- Mobile antennas



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features

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and Scott A. McFarland

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26 Coverage proof of performance: Hocus-pocus or real-world?

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34 Servicing pagers: And you shall receiver knowledge . . .

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40 How to select antennas for mobile radio systems

Ronald Steen

The antenna is important to all mobile radio systems. Often, it is more cost-effective to improve the antenna for better coverage than to improve receiving system sensitivity or to increase transmitter power.

On the cover: Michael Kingrey, a radio dispatcher with the Kansas City Area Transportation Authority ("The Metro"), Kansas City, MO, communicates with the 210-bus fleet.

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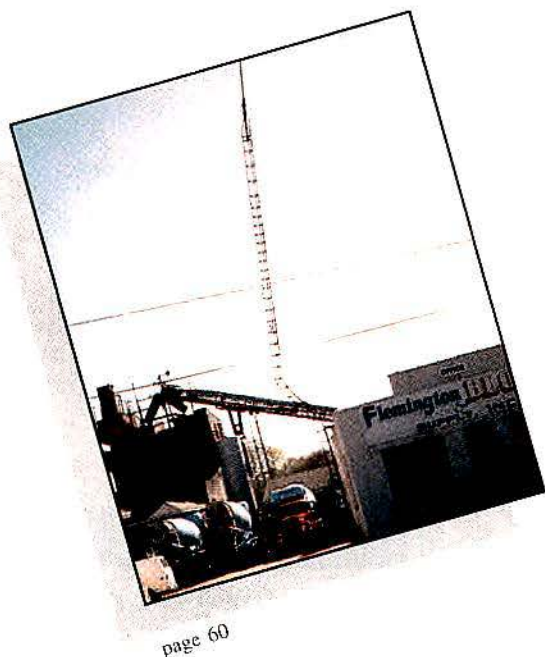
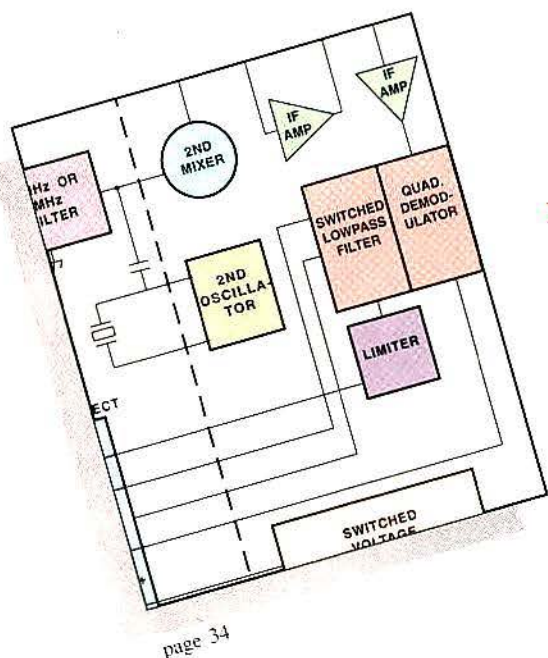
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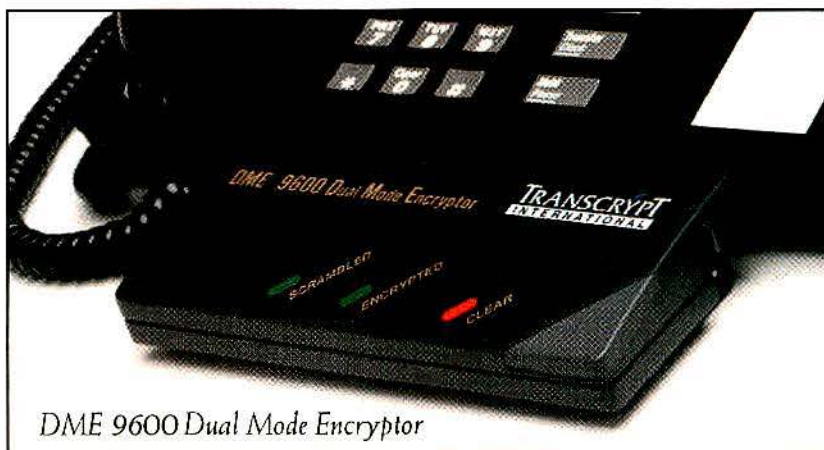


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What's narrowband PCS? A wireless pocket answering machine!



Names initially given to communications services sometimes do not fit. "Cellular radio," for example. Remember? That's what cellular telephony was called, before anyone had to sell the service. First the business users, and then members of the public, paid to use cellular *telephones*, not *radios*. "Cellular" became synonymous with—at first—mobile phones, and then portable phones. Cellular phones.

Another communications service is starting out with a name that will not last long: "Narrowband PCS." (PCS stands for personal communications service.) No one is going to sell "narrowband PCS" service to the public.

Plano, TX-based PageNet, for example, is going to sell "VoiceNow wireless pocket answering machines." People who call VoiceNow subscribers will record their voice messages over the phone. Individual subscribers will receive their messages by radio on a pocket-size electronic recorder ... aaahh, that is, a wireless pocket answering machine. About 60% of American households are said to have answering machines. You can sell a wireless pocket answering machine. Who can sell a narrowband PCS digital voice-messaging electronic playback unit? Even if you call it a pager?

The difference between "digital paging" and "wireless pocket answering machines" helps to restore voice paging to large cities where it has been replaced by numeric paging. Voice paging was replaced because it uses analog transmission. In the time required for one analog voice message, several digital numeric messages can be sent. Paging service providers make more money—even at lower prices—by sending a high volume of digital numeric messages in place of voice messages. In

large cities where customer demand allows service providers to fill their airtime, voice is out, and numeric is in.

Four-level modulation and a flexible code developed by Motorola compress voice transmission as a digital signal, transmitting voice swiftly enough to fit the limited airtime available. The voice message recorded by the caller is transmitted to the subscriber unit in a fraction of the time it took to speak it. When played back from electronic memory in the subscriber unit, the message sounds the way it was spoken. Hence: wireless pocket answering machine.

* * *

Identity crisis

Public and investment community perception of two-way radio dispatch lacks sizzle. What's dispatch? And isn't two-way radio only for taxis and squad cars?

Many people want to rename this communications technology to make it more clear or more attractive (maybe both). Alan Shark, president of American Mobile Telecommunications Association, suggests "business communication networks." Craig McCaw, who, with his family, plans to invest as much as \$1.1 billion in Nextel Communications, refers to target customers as "mobile work groups." Christopher Galvin, president of Motorola, said his company has renamed the "Motorola Integrated Radio System" as "Integrated Dispatch Enhanced Network" ... maybe a step *toward*, rather than *away*, from using the word "dispatch." Gary F. Ballard, an area vice president for OneComm, who visited one day to demonstrate the Unicator integrated communications handset, referred to the dispatch portion of OneComm network services as an "executive intercom."

Any other ideas?

* * *

Produce, meat and cellular

When authorities on wireless telephone distribution wanted to express their version of the ultimate retail outlet for cellphone sales, they would speak of the day to come when cellular telephones could be purchased in supermarkets. That day has come.

Thanks to an agreement between BellSouth Cellular and Kroger, supermarket shoppers in several cities can stop at self-contained kiosks and purchase cellular telephones and services prior to shopping. By the time they have checked out

and are ready to leave, an activated phone will be awaiting them ready for immediate use.

BellSouth Cellular's presence in supermarkets will allow the company to reach one of the fastest-growing consumer segments, women between the ages of 25 and 44. Kiosks are operational in 36 Kroger stores in Indianapolis; Nashville, TN; Huntsville, AL; and Clarksville, TN; with stores in Atlanta; Louisville and Lexington, KY, due to be added this month.

* * *

A cold day in ... Washington

On April 5, the FCC Wireless Telecommunications Bureau placed a moratorium (a "freeze") on filing new applications for intercategory sharing on private mobile radio service (PMRS) channels in the 806MHz–821MHz and 851MHz–866MHz bands.

The federal government has shown no lack of imagination in finding ways to interfere with the growth of private land mobile radio systems in the 800MHz band. This time, with one private radio trade association pitted against the others, the FCC found it easy. The Association of Public-Safety Communications Officials—International (APCO) asked the commission to stop letting non-public-safety entities apply for private radio licenses on public-safety frequencies.

Since 1982, reciprocal procedures have allowed entities to apply for frequencies outside their nominal categories. Public safety entities could apply for non-public-safety frequencies and vice versa when frequencies in their own category were filled in a given geographic area. There is no good reason to change this arrangement, and it is unfortunate that one part of the private radio industry has given the FCC an excuse once again to deal a setback to another part of the private radio industry.

—Don Bishop

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- 16-19—**Forestry Conservation Communications Association**, Edison Whalhall Hotel, Jackson, MS. Contact: Joyal Watkins, 601-354-6008.
26-28—**Vehicular Technology Conference**, sponsored by IEEE Vehicular Technology Society, Hyatt Regency Chicago O'Hare, Chicago. Contact: Keith Paglusch, chairman, 312-399-2378.
31-Aug. 4—**Utilities Telecommunications Council**, Hyatt Regency and Convention Center, Minneapolis. Contact: 202-872-0030.

August

- 13-18—**Association of Public-Safety Communications Officials—International National Conference**, Detroit. Contact: 800-949-2726.

September

- 20-23—**Personal Communications Showcase**, sponsored by the Personal Communications Industry Association (PCIA), Orange County Convention Center, Orlando, FL. Contact: 800-326-8638.

October

- 16-18—**International Conference on Power Requirements for Mobile Computing and Wireless Communications**, sponsored by BIS Strategic Decisions, Santa Clara Westin & Convention Center, Santa Clara, CA. Contact: 617-982-9500.
18-20—**International Wireless Communications Expo/Fall has been canceled.**
26—**ERA Communications Trade Fair**, Ala Moana Hotel, Honolulu. Contact: 310-287-1218.
29-Nov. 1—**Wireless Apps**, sponsored by the Cellular Telecommunications Industry Association, The Mirage Hotel, Las Vegas. Contact: 202-785-0081.

November

- 7-9—**WirelessWorld Conference and Exposition**, sponsored by *Cellu-*

lar Business and Mobile Radio Technology magazines, Moscone Convention Center, San Francisco. Contact: Chris Lotesto, 800-458-0479.

- 8-12—**Communications Marketing Conference**, sponsored by the Communications Marketing Association, Albuquerque, NM. Contact: Bernie Brownson, 303-371-8182.

- 17—**Radio Club of America**, Communications Symposium, 86th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Ron Formella, 201-652-6811.

1996

March

- 23-25—**Wireless '96**, sponsored by the Cellular Telecommunications Industry Association, Dallas. Contact: 202-785-0081.

April

- 24-26—**International Wireless Communications Expo/Spring**, Las Vegas Convention Center, Las Vegas. Contact: 800-828-0420.

June

- 24-27—**Supercomm**, sponsored by USTA and TIA, Dallas Convention Center, Dallas. Contact: 202-326-7300.

July

- 11-13—**Communications Expo/Show of the Americas**, Miami, FL. Contact: 305-229-9992.

September

- 19-21—**Personal Communications Showcase**, sponsored by the Personal Communications Industry Association (PCIA), San Francisco. Contact: 800-326-8638.



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The journal of mobile communications technology

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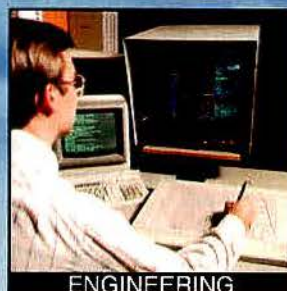
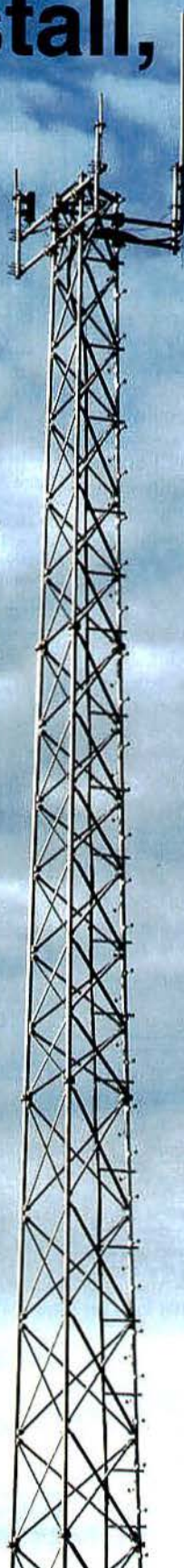
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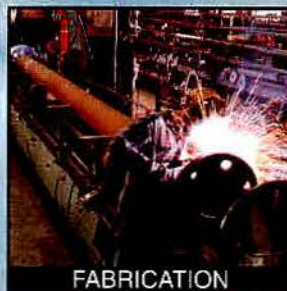
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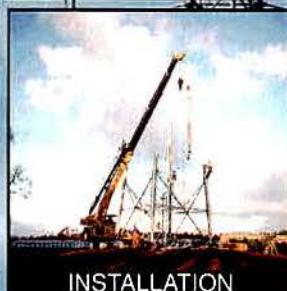
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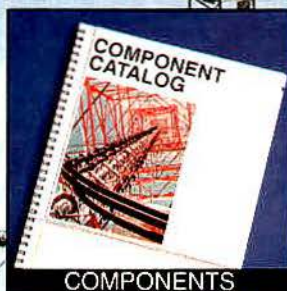
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How attenuator pads improve impedance matching

By Harold Kinley, C.E.T.

Unless special precautions are taken, impedance discontinuities can cause severe reflections that can adversely affect a test procedure and circuit operation. Although an attenuator pad injects loss into the system, the loss usually can be overcome. Loss caused by the pad is a small tradeoff for the great improvement in impedance smoothing it provides. In fact, the word "pad" describes the job the attenuator performs—it provides padding at a point in a system or chain where abrupt changes in impedance would otherwise cause a severe reflection.

An analogy is the job performed by the shock absorber on your car. Without it, you would feel every little bump in the road, but with it even the big bumps are reduced to minor ones.

How it works

Figure 1 below shows a signal generator connected to a receiver. It is important for the signal generator to see a proper (50Ω) impedance at its output port. If the load (receiver) presents an impedance other than 50Ω to the generator, the validity of any test procedure might be impaired by reflections on the line. The interconnecting transmission line would become resonant, and the impedance presented to the signal generator would be a complex impedance with inductive or capacitive reactance, depending on the length of the transmission line. In Figure 1, the receiver represents a complex impedance of $30 + j40$ ohms.

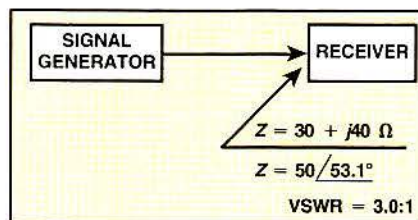


Figure 1. The receiver input presents a complex impedance of $(30 + j40)$ ohms to the signal generator. This causes an SWR of 3:1. The complex impedance is also shown in polar form as 50Ω at an angle of 53.1° .

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985. He is a member of the Radio Club of America.

In Figure 2 below the impedance at the load end (point E) is complex. That is, it consists of a reactance and a resistance as

shown. The complex impedance is represented by the expression $30 + j40$ ohms.

(continued on page 46)

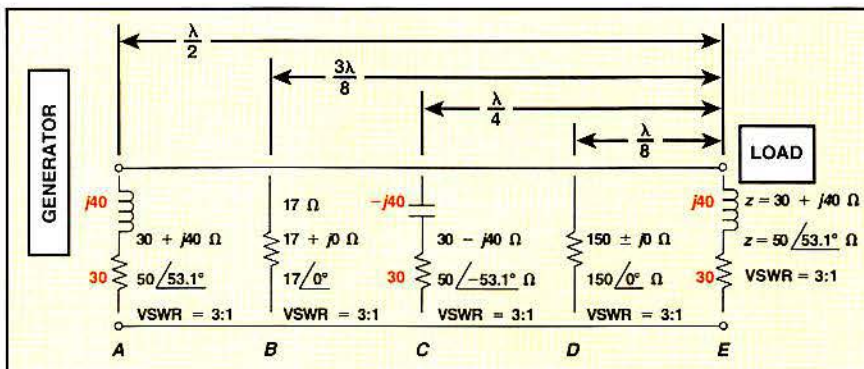


Figure 2. This expands upon the setup in Figure 1. Here, the signal generator is connected to the receiver input via a lossless transmission line that is one-half wavelength ($\lambda/2$) long. The VSWR is the same at all points along the transmission line. However, the impedance will vary along the line and will repeat every half-wavelength ($\lambda/2$). At two points ($\lambda/8$ and $3\lambda/8$) the impedance is purely resistive. However, the pure resistance is still such that the VSWR is still 3:1. This assumes a 50Ω transmission line and 50Ω system impedance.

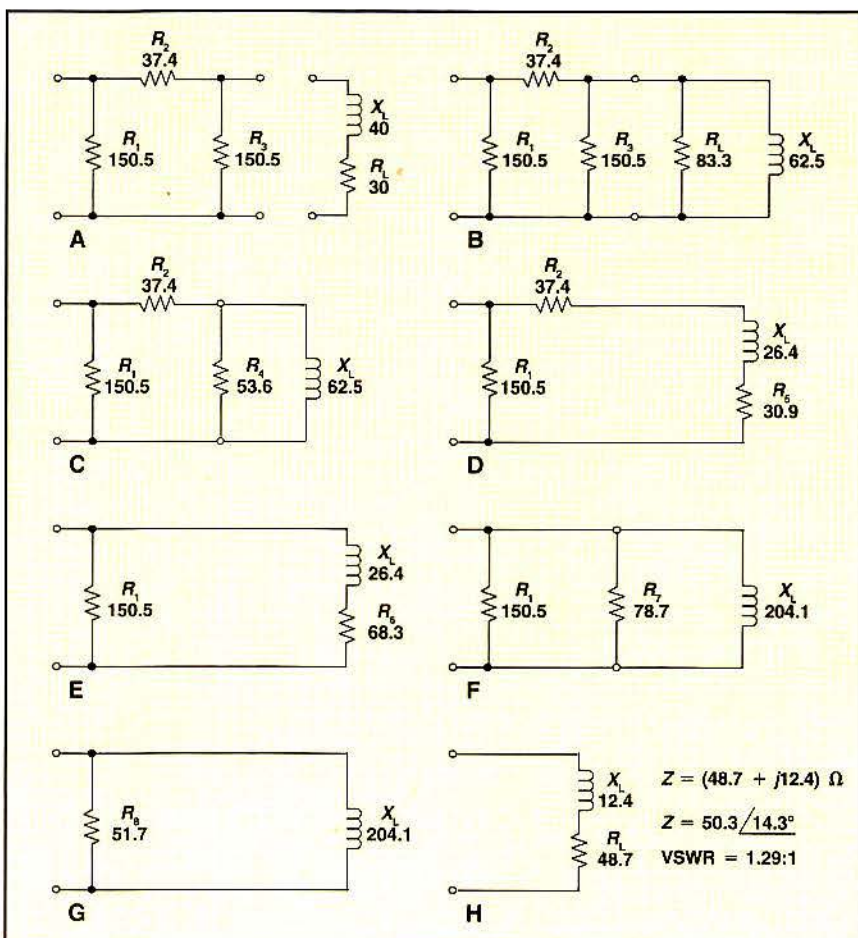


Figure 3. This illustrates through evolution how a 6dB pad transforms the output impedance to the impedance that is "seen" at the pad input. The output impedance, $(30 + j40)$ ohms, would cause a VSWR of 3:1. However, looking at the input to the pad, the generator or source would see an impedance of $48.7 + j12.4$ ohms for a VSWR of 1.29:1.

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Data analysis aids setup of Flex paging channels

Efficient Flex paging data analysis and channel management requires an ability to view captured data, to log files to a disk and to view multiple, real-time displays simultaneously.

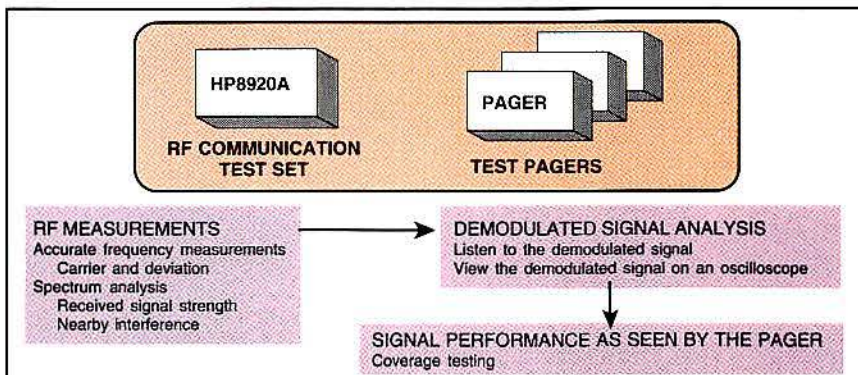
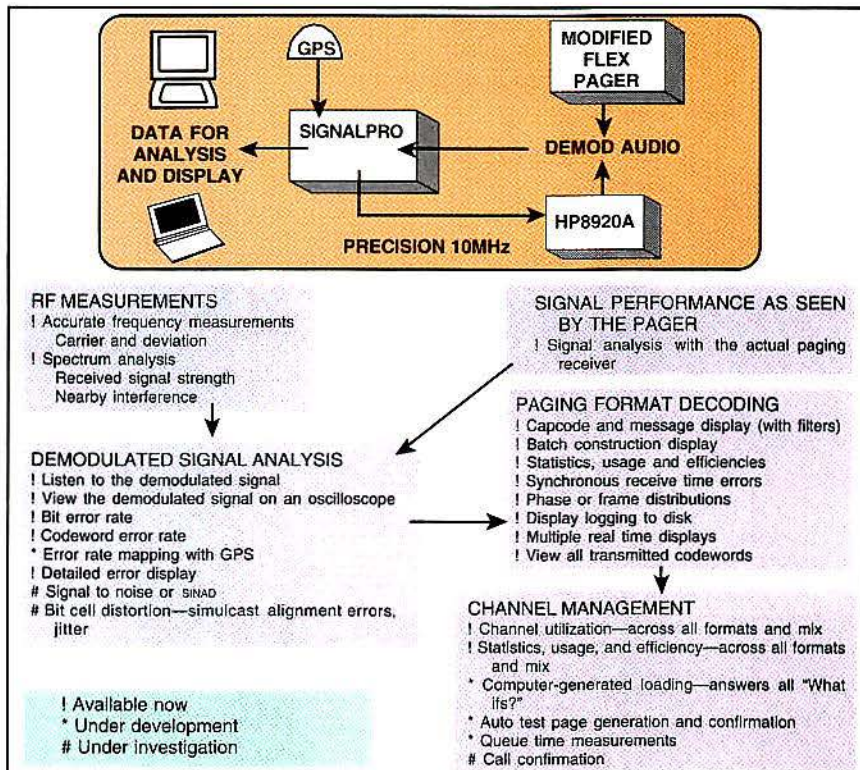


Figure 1. A standard method for testing a paging system before customer loading consists of an RF sanity check and coverage testing using pagers. There are weaknesses with this approach when it is applied to the deployment of Flex.



By Steven M. Sandercock
and Scott A. McFarland

Adding Motorola's Flex (flexible wide-area synchronous protocol) paging format to an existing paging channel, or installing Flex infrastructure on a new paging channel, presents a formidable technical challenge.

The format represents a quantum leap in complexity. Traditional formats are asynchronous, 2-level frequency-shift keying (FSK), whereas Flex is fully synchronous and can operate at 4-level FSK. Transmission data rates have also increased dramatically from a maximum of 2,400bps to 6,400bps. Moreover, every system component has undergone, or is undergoing, radical change to produce Flex high-speed paging data. Terminal equipment, link distribution methods and equipment, transmitter controllers, excitors and pagers are each significantly different from their POCSAG predecessors.

With multiple changes taking place in the system at the same time, technical managers must formulate a test-and-measurement strategy that goes well beyond transmitter adjustments and RF coverage testing. Fundamental simulcast radio measurements, signal analysis and format-specific data decoding

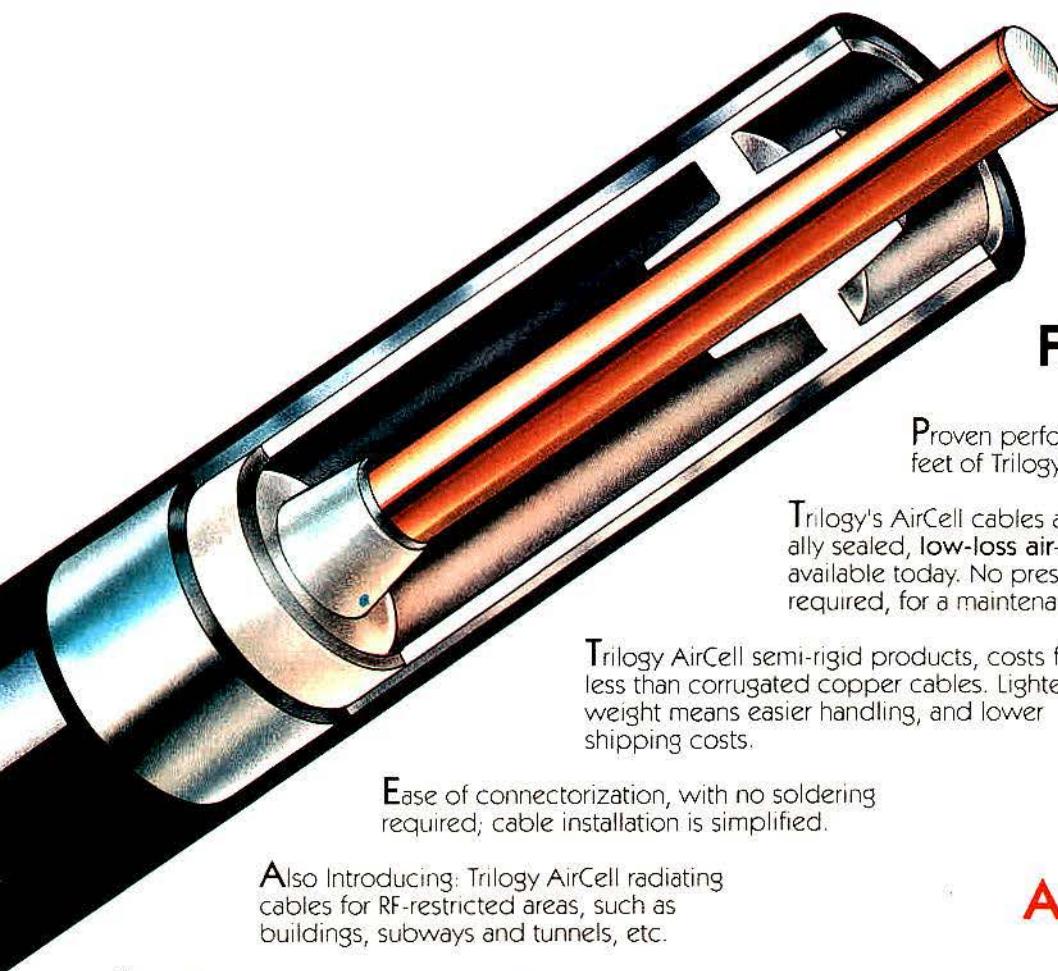
Figure 2. Much more information about Flex system operation can be gathered, analyzed and displayed with a modular, portable system consisting of a Signalpro paging data analyzer, a modified Motorola ProEncore or NEC Message Maker Exec Flex pager, a laptop or desktop personal computer and an RF test set such as a Hewlett-Packard HP8920A.

Sandercock is president, and McFarland is chief technical officer at Advanced Signal, Quincy, IL. Advanced Signal manufactures the Signalpro paging data analyzer described in the article.

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Circle (9) on Fast Fact Card

are necessary to construct and load high-speed paging channels.

Standard testing method

A standard method for testing a paging system before customer loading consists of an RF sanity check and coverage testing using pagers. (See Figure 1 on page 10.) The RF check involves measuring, and possibly setting, each transmitter's carrier frequency, deviation and data polarity.

This step is almost universally performed using an RF communications test set.

Technicians then move to selected areas and, using the spectrum analyzer within the RF test set, verify the expected received signal strength and identify any significant in-band or adjacent-channel interference. Once the RF sanity check is completed, technicians armed with a handful of pagers are dispatched to conduct coverage tests in selected areas. The idea

Five test measurements

Paging system test measurements required for a successful transition to Flex include:

- ☐ RF measurements
- ☐ Signal performance
- ☐ Signal analysis
- ☐ Paging format decoding
- ☐ Channel management

of using pagers to provide real-life test results is fundamentally sound. The bottom line is that your customers use pagers, and pager performance is critical.

There are weaknesses with this approach when it is applied to the deployment of Flex. The accuracy of the RF measurements needed for Flex requires that the RF test set be locked to a known frequency standard, e.g., the Global Positioning System (GPS). In addition, coverage testing with pagers assumes that the only system parameters in question are those that affect coverage. When adding Flex, remem-

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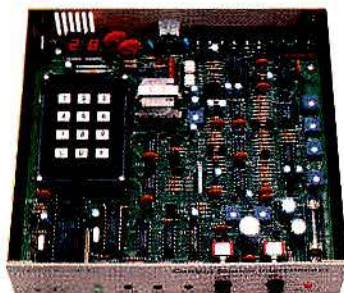
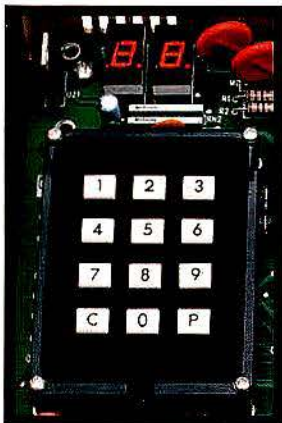
The biggest challenge in implementing Flex is how to locate and analyze simulcast misalignment.

ber that most of the infrastructure is new or has been significantly upgraded. Coverage testing with pagers does not provide sufficient information to ensure compliance with all of the different paging format requirements. This type of coverage testing is also time-consuming and does not provide a precise measurement of the signal degradation in marginal performance areas.

Simulcast misalignment

The biggest challenge in implementing Flex is how to locate and analyze simulcast misalignment. Consider that an increase in the paging data rate decreases the tolerable simulcast alignment error. In the simplest case, 2,400-baud data has an allowable alignment error of 104µsec (or one-fourth the time of a bit). The tolerable error for 3,200-baud data is 78µsec. Simulcast system operators know that, in large systems, significant overlap areas can extend for miles. At a propagation rate of 5.4µsec per mile, the change from 2,400-baud to 3,200-baud data results in a five-mile decrease in the diameter of the

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A low cost interconnect that can be used straight simplex or through any conventional or trunked repeater system. (Please see export note below).

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'AutoRemote' allows every phone on a KSU or PBX to double as a Radio Remote. Electronic Voice Delay is standard. Please note that the 6800 is not an interconnect and can be used in any city in the USA.

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Circle (11) on Fast Fact Card

Slot 2 [931.XXXG] Hourly Usage/Efficiencies

Last Date: FLEX 6400 04/02/1995 18:16:31 0°0'0"E 0°0'0"N

	08:00-07:00	08:00-15:00	15:00-23:00	
Batch Efficiency (%)	12.01	0.00	0.00	41.69
HR20-Page Time	230.67	0.00	0.00	1,801.92
Idle Time	202.92	0.00	0.00	610.48
Total Pages	36	0	0	9,374
Alpha Pages	4	0	0	1,760
Numeric Pages	32	0	0	7,614
Ave Alpha Length	67.25	0.00	0.00	54.00
Ave Numeric Length	11.94	0.00	0.00	13.04
Batch Efficiency (%)	12.03	0.00	0.00	74.06
HR21-Page Time	221.29	0.00	0.00	1,194.68
Idle Time	194.67	0.00	0.00	314.41
Total Pages	21	0	0	2,233
Alpha Pages	5	0	0	1,350
Numeric Pages	16	0	0	5,883
Ave Alpha Length	50.00	0.00	0.00	53.47
Ave Numeric Length	13.38	0.00	0.00	13.08
Batch Efficiency (%)	12.03	0.00	0.00	73.66
HR22-Page Time	221.29	0.00	0.00	894.99
Idle Time	195.30	0.00	0.00	235.17
Total Pages	14	0	0	5,442
Alpha Pages	5	0	0	956
Numeric Pages	9	0	0	4,486
Ave Alpha Length	74.50	0.00	0.00	55.53
Ave Numeric Length	13.22	0.00	0.00	12.99
Batch Efficiency (%)	11.75	0.00	0.00	73.71
HR23-Page Time	219.42	0.00	0.00	791.33
Idle Time	194.76	0.00	0.00	194.36
Total Pages	10	0	0	4,182
Alpha Pages	3	0	0	739
Numeric Pages	7	0	0	3,443
Ave Alpha Length	29.00	0.00	0.00	76.15
Ave Numeric Length	10.43	0.00	0.00	13.16
Batch Efficiency (%)	11.24	0.00	0.00	75.44
Total Page Time	1,790.97	0.00	0.00	14,543.91
Total Idle	1,571.55	0.00	0.00	3,162.00
Total Pages	321	0	0	96,877
Total Alpha	62	0	0	19,423
Total Numeric	259	0	0	77,454

Photo 1. The hourly usage and efficiencies display provides detailed, real-time information about batching efficiency.

acceptable overlap area. This problem is accentuated when transmitters of differing tower heights, and effective radiated power (ERP) levels are used within the system. Keep in mind that the signal strength in this scenario does not change when the data rate increases.

It seems impractical to repeat coverage tests indefinitely until the new coverage boundaries are determined. How can an operator quickly locate and identify these areas?

Comprehensive signal analysis

Contrast the system information available using the standard method with that depicted in Figure 2 on page 10. This modular and portable system consists of a signal analyzer, a modified Motorola ProEncore or NEC Message Maker Exec Flex pager, a laptop or desktop personal computer and an RF test set such as a Hewlett-Packard HP8920A. The measurement areas are focused into five categories required for a successful transition to Flex.

(1) RF measurements can be obtained

GAMBER-JOHNSON

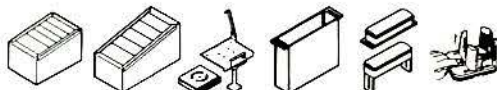
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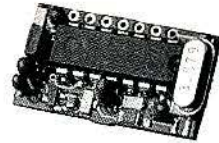
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Q

VPU-8



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- ♥ Single code inversion scrambler
- ♥ Motorola VPA compatible
- ♥ Simultaneously scrambles & descrambles
- ♥ Crystal controlled for high stability
- ♥ Very good recovered audio quality and speaker recognition
- ♥ Single input lead takes a ground to change between scramble and clear
- ♥ Available with flying leads

A

10

VPU-7



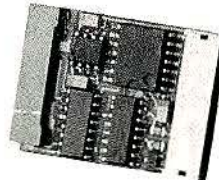
Smallest Simplex Inversion Scrambler

- ♥ Ultra-thin simplex inversion scrambler
- ♥ Single code scrambler
- ♥ Anti-aliasing input filter
- ♥ Crystal controlled for high stability
- ♥ Excellent recovered Audio Quality
- ♥ Microminiature quick disconnect connector with color coded leads for simplified installation and removal. Available with optional flying leads.



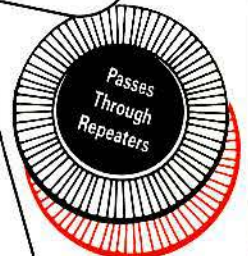
J

VPU-2



Subminiature Tunable Voice Inversion Scrambler

- ♥ Easily tuned with high-stability 15-turn trim pot
- ♥ Anti-aliasing input filter
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- ♥ Simplex operation
- ♥ Excellent recovered audio quality
- ♥ Microminiature quick disconnect connector with color coded leads for simplified installation and removal. Available with optional flying leads.



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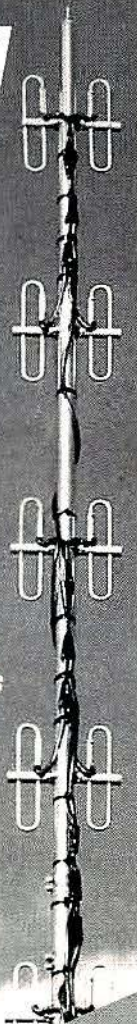
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Slot 2 (031.XXXX) - Channel Metrics

Metrics Start: 04/06/1995 16:51:55 Last Date: POCSAG 2400 04/07/1995 07:51:55 0°0'0"E 0°0'0"N

	FLEX 8400	FLEX 3200-4	FLEX 3200-2	FLEX 1600	POCSAG 2400	POCSAG 1200	POCSAG 512	TOTAL
CHANNEL								
Total Calls	33,690	0	0	0	87,129	11	0	120,830
EFFICIENCY								
Calls/Second	0.55	0.00	0.00	0.00	2.46	0.01	0.00	
Codewords/Second	3.08	0.00	0.00	0.00	13.80	0.04	0.00	
ERROR RATES								
Bit (x10E-06)	27.02	0.00	0.00	0.00	10.86	0.00	0.00	
Codeword (x10E-09)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SYNC ERRORS								
Peak (us)	-83	0	0	0				
Last Measured (us)	0	0	0	0				

Photo 2. The channel metrics display shows calls per second, codewords per second, hourly use and efficiency for 'before' and 'after' comparisons of implementing Flex.

from the RF test set when driven by a precision 10MHz frequency reference. The 10MHz reference can be obtained from a signal analyzer locked to GPS or possibly from the transmitter controller when the test setup is used at a transmitter site.

(2) *Signal performance* can be analyzed by using a modified pager to provide audio to the paging data analyzer.

(3) *Signal analysis* is greatly expanded by the paging data analyzer, which includes bit error rate (BER) and codeword error rate (CWER) analysis.

(4) *Paging format decoding* for POCSAG and Flex is performed by the paging data analyzer. A high-speed digital signal processor (DSP) within the paging data analyzer performs all the demodulated signal analysis. The DSP accepts decoupled audio from one of several sources: the receiver within an actual ProEncore or Message Maker Exec pager, a modified scanner or an RF test set.

(5) *Channel management* information such as average numeric and alphanumeric message length, batch efficiency and channel use is provided by the paging data analyzer and PC console.

present a significant challenge. The successful carrier maximizes technician productivity by rapidly identifying areas where the simulcast error exceeds tolerable limits. This identification requires analysis and measurement of the demodulated audio signal. Signal analysis allows the operator to quantify errors received in the transmission. The paging data analyzer calculates BER and CWER using the paging format's forward error-correction protocol. This calculation provides the system operator with the most accurate measure of successful paging.

A few modifications transform a ProEncore or Message Maker Exec pager into a receiver for the signal analyzer. The modified receiver allows the Flex pager to pass demodulated audio, regardless of the paging format, to the analyzer. Together they form a powerful and portable signal analysis system. Light-emitting diodes (LEDs) on the front of the paging data analyzer indicate bit errors and code word errors, providing a highly mobile and console-free operating mode.

Testing the system

The first task is to find areas with consistent codeword errors. The console and a communication test set should be taken to

Accurate measurements

As mentioned earlier, adding Flex can

Slot 2 (031.XXXX) - Capcode/Message

File Logging: OFF Filters: None

```

00214_547 = AC = 130 1000
00214_548 = AC = 130 1000

FLEX 8400 03/01/1995 12:00:00 03/01/1995 12:00:00
Cycle: 1. Message: 05 000: 1 byte Rx (hex): 21
00214_547 = AC = 100015 000000 FLEX 8400
00214_548 = AC = 130 1000
  
```

Photo 3. Capcode and message data show actual paging activity and help to diagnose possible system problems.

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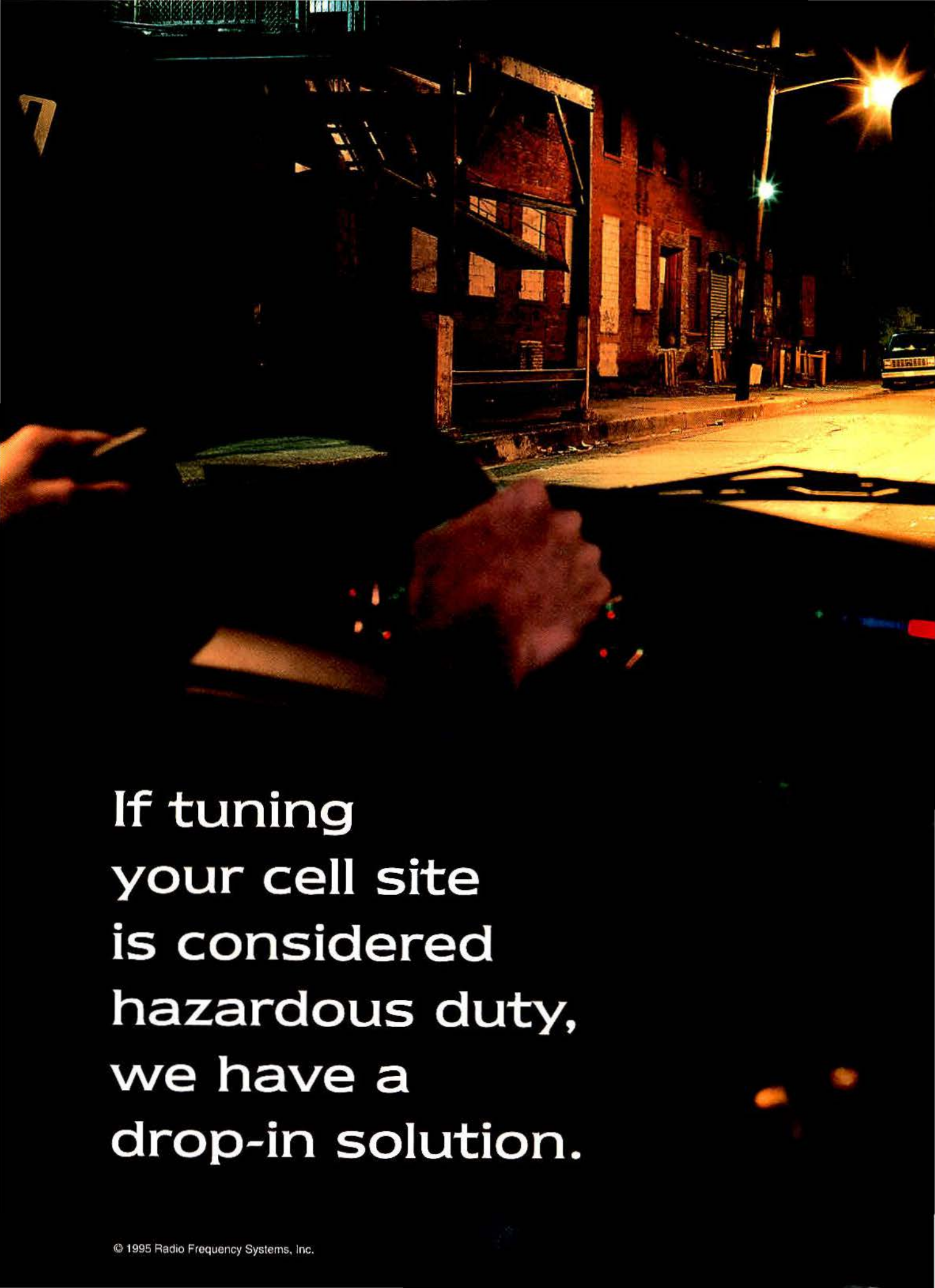
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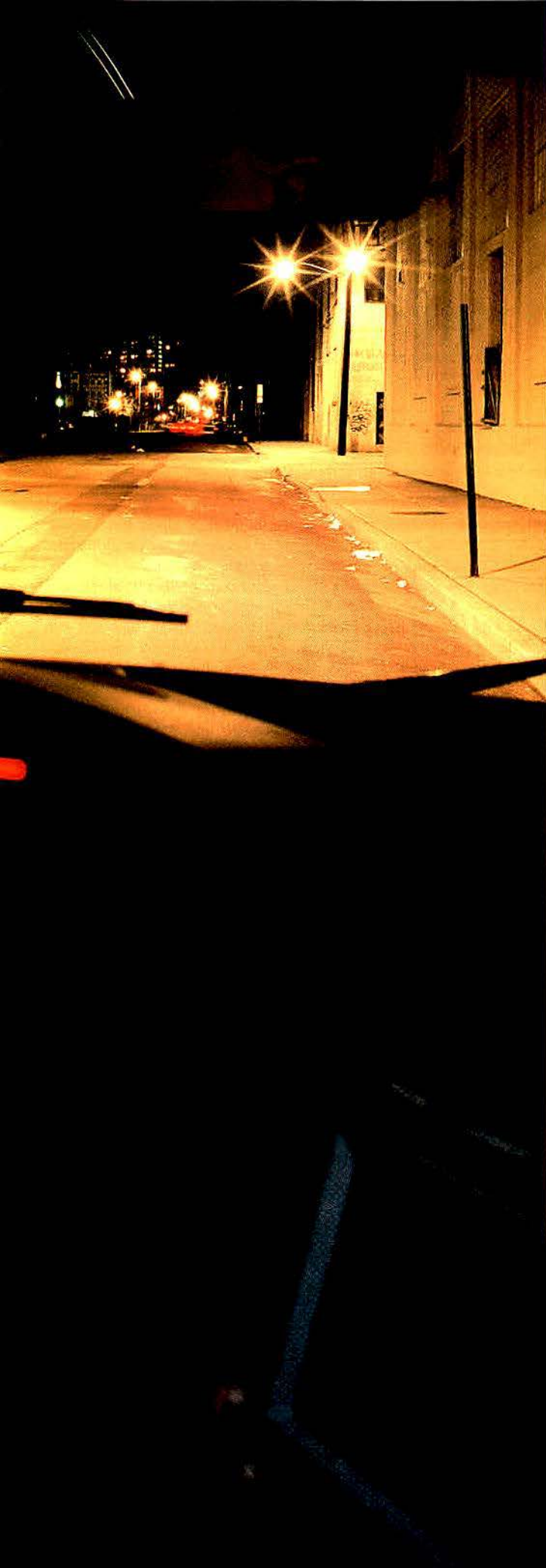
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Circle (15) on Fast Fact Card

A person is shown from the chest up, sitting in the driver's seat of a vehicle at night. They are holding a radio in their right hand and appear to be tuning it. The interior of the vehicle is dark, with some dashboard lights visible. Outside the vehicle, a city street is visible at night, illuminated by streetlights. In the background, there are brick buildings, some of which appear to be under construction or renovation, with scaffolding visible. A car is parked on the street in the distance. The overall scene is dark and moody, with a focus on the person's action of tuning the radio.

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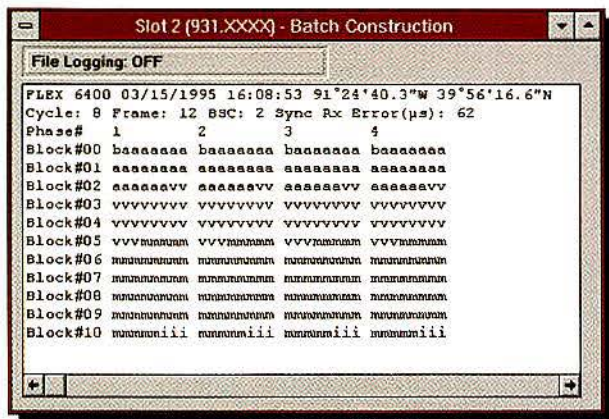
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Circle (16) on Fast Fact Card



Photos 5 and 6. The *batch construction* and *detailed channel error* displays help to determine the effectiveness of the encoder controlling a paging channel.

those areas for in-depth troubleshooting. Technicians can then re-evaluate transmission errors after deactivating one or more of the surrounding transmitters. Identifying the location and cause of unacceptable error rates is required information to make informed decisions concerning additional transmitters, antenna heights and power levels.

Paging format decoding (paging data analysis) is as important to your overall

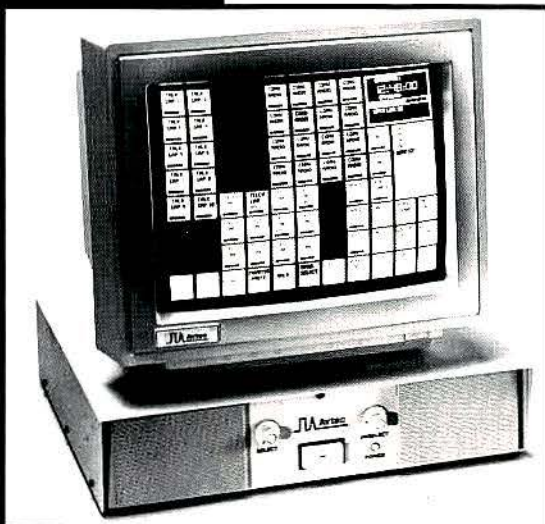
understanding of a high-speed signaling system as signal analysis. Decoding helps to identify pager or encoder problems as new systems are loaded or as new services are brought on line.

The *hourly usage and efficiencies* display on the paging data analyzer provides detailed, real-time information about the batching efficiency of a particular paging format and rate, or the overall use of a paging channel. (See Photo 1 on page 14.)

Total pages, number of alpha and numeric pages, and average length of alpha and numeric pages are provided.

Calls/sec and codewords/sec, along with the hourly usage and efficiencies display, characterizes the subscriber mix and can be viewed under the *channel metrics* display. (See Photo 2 on page 16.) This information can be entered into the closed-loop test program, allowing the carrier to better determine the "before" and "after" effects

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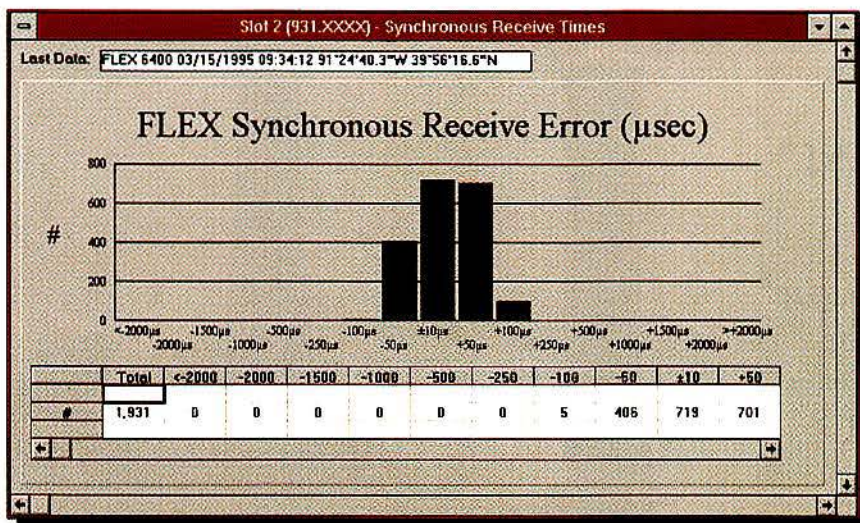


Photo 6. The *Flex* synchronous receive error display tracks whether the new infrastructure is producing (and mixing) POCSAG and Flex data according to the defined protocol timing standard.

of implementing Flex. Understanding how a system will be affected by adding Flex allows the transition to be managed better.

Capcode and message data are used to show actual paging activity. (See Photo 3 on page 16.) Used in conjunction with filtering options, they also provide a tool to

diagnose possible system problems.

Phase and slot distributions are viewed under the *call count display*. The information is used to convey the spread of pager addresses over the range of slots, phases, groups or preambles (depending on the format). This information is particularly

helpful with respect to implementing Flex on existing paging channels.

Batch construction and detailed channel error provide detailed, real-time information about each paging format and can provide information to determine the effectiveness of the encoder controlling a paging channel. (See Photos 4 and 5 on page 20.)

The *Flex synchronous receive error display* tracks whether the new infrastructure is producing (and mixing) POCSAG and Flex data according to the defined protocol timing standard. (See Photo 6 to the left.)

Channel management

Once the paging system is fine-tuned, you will need to manage channel loading to provide the most efficient system possible. The fundamental reason for adding Flex to an existing channel or constructing a new channel is to increase channel capacity and subscriber throughput. The paging data analyzer provides a complete set of channel management tools. Particularly useful are the hourly usage and efficiencies, calls/sec and codewords/sec, and phase and slot distribution information.

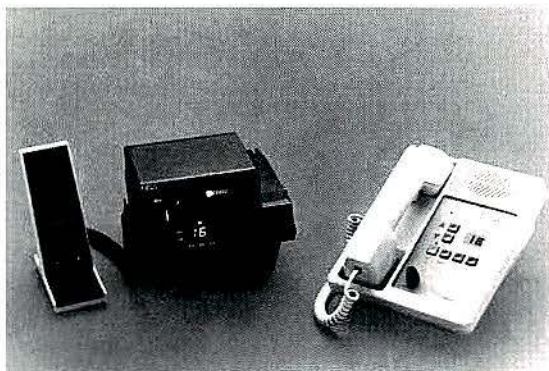
Also required is a closed-loop system test that provides a Telocator Network Paging Protocol (TNPP) load generation program, which allows you to generate periodic test pages and to conduct queue time studies. In addition, the program can load a full channel, and you can conduct in-house testing of paging encoders prior to purchasing a new product, or you can test and validate a new encoder software release prior to implementation in a live system. You also have the ability to devise "what if" scenarios to determine new system requirements or the cost-effectiveness in changing from a particular paging format and rate to a higher-speed format.

Three key elements affect efficient paging data analysis and channel management. First is the ability to view captured data on a PC via a scrollbar buffer. Second is the ability to log files to a disk to provide a detailed, historical record of paging channel activity. Third is the capability of viewing multiple, real-time displays simultaneously. Each of these elements is present in the paging data analyzer.

Carriers will find it necessary to have a comprehensive signal analysis and channel management tool as Flex channels are constructed and loaded. Using a paging data analyzer in conjunction with an existing RF test set and a modified pager provides the complete solution for conducting RF measurements, signal analysis and paging format decoding.



GET CONTROL...



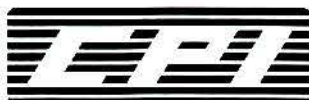
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- Radio transmissions monitored on remote speaker.
- Uses any two wire voice grade circuit.



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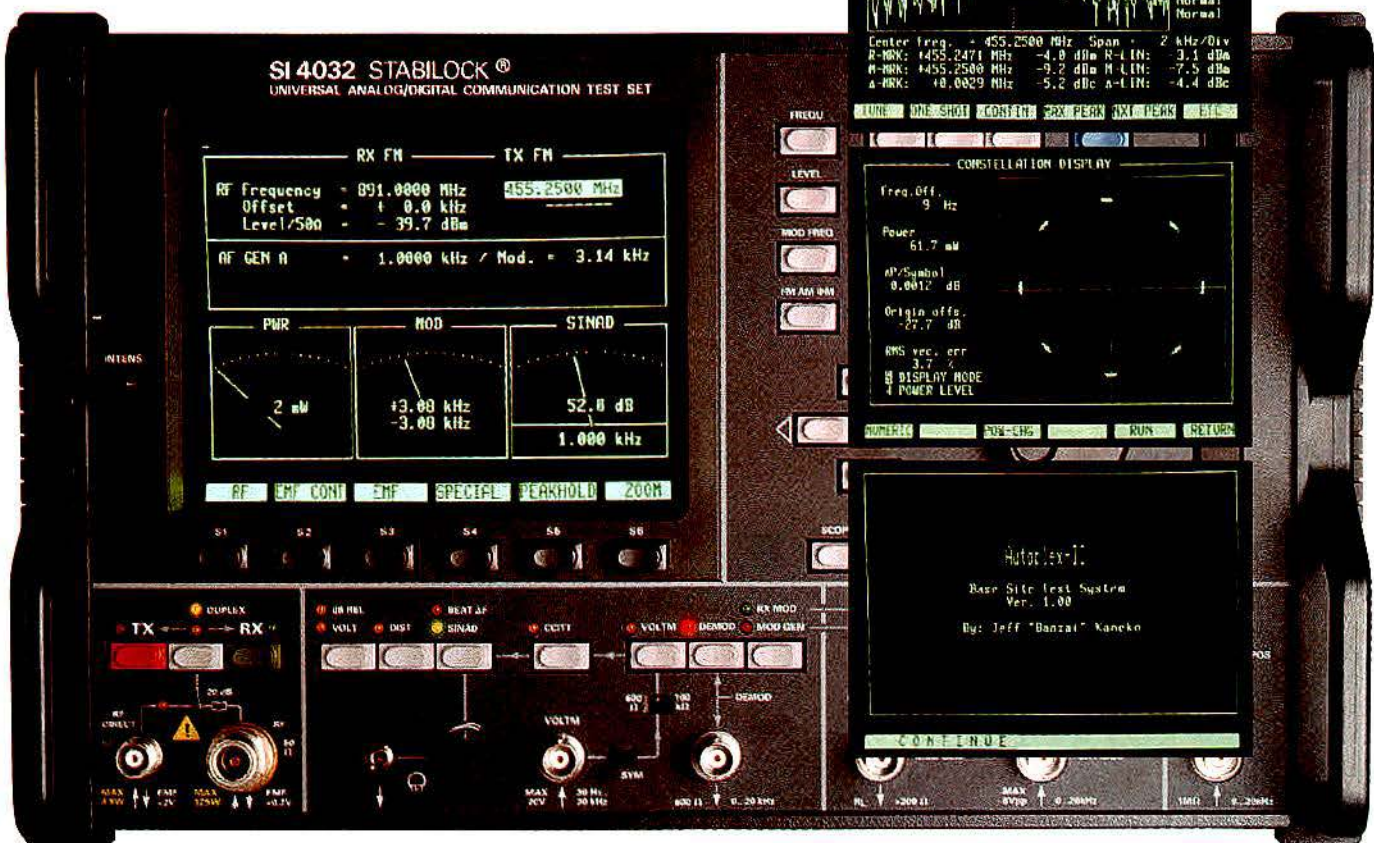
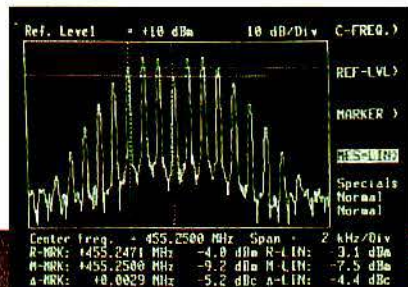
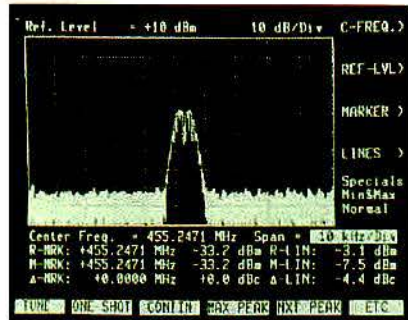
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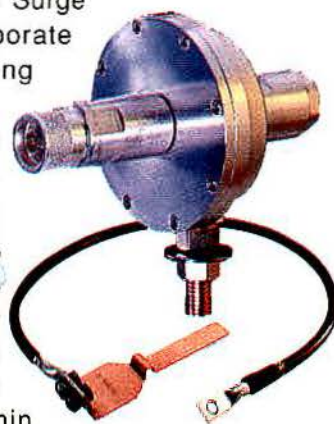
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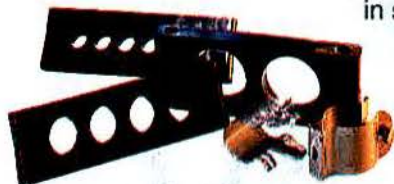


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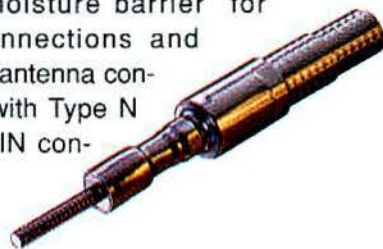
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Coverage proof of performance: Hocus-pocus or real-world?

Part 2—All elements, from the initial needs assessment through procurement to implementation and final testing, must effectively integrate. Consider using assistance from professionals who have been through the process.

By Robert T. Forrest, P.E.

Grade of service, availability and service area are three specifications that have a lot to do with satisfactory radio communications and coverage proof of performance.

► *Grade of service* — In voice communications, the ultimate goal is the *understandability* (as opposed to the more subjective *quality*) of the voice message. For analog systems, circuit merit as shown in Table 1 below is a good measure of understandability. The table defines typical analog signal levels needed in a low-noise area. The design target minimum is generally CM-3, or *minimum commercial*. For digital voice systems, the signal levels may differ. In general, a system designed to provide adequate analog operation will perform equally well and sometimes better under a digital configuration.

A typical *grade of service* specification might read:

"Median 0.5µV signal at the receiver antenna terminals."

► *Availability* — Do not let the statistics game get to you. You can pay dearly

for overspecified availability. It is hard to tell the difference between 95% and 90% availability anywhere but in your pocket-book. You could pay a 20% to 40% premium in added sites, higher towers and other equipment to increase availability from 90% to 95%.

Many new-system coverage complaints are *perceived problems*: They reflect a situation where a user had coverage at a particular location in the previous system, yet no longer has it. No matter that the new system got rid of 10 dead spots, the one *new* dead spot is uppermost in the user's mind.

An availability of 90% is normally adequate for most utility and industrial service areas, and this criterion has withstood the test of time. The 95% target is used for public safety and is tough to hit. If you were to measure your current system, you would probably find that its coverage is much less than 95% or even 90%.

Remember that a key characteristic of a *trunked* system is that the user does not hear most of the ongoing radio traffic, so the user often cannot tell when the unit is traveling out of range. Because of this

characteristic, a change to a trunked system with the same percentage availability as the conventional system it replaces probably will be *perceived* by users as a decrease in coverage.

A typical availability specification might read:

"90% of the randomly selected locations within the required service area."

► *Service area* — Define service area by describing where you need to talk regularly. You may want to specify different conditions associated with different service areas. Figure 1 on page 28 shows how a major eastern city might specify "inside building coverage." One building penetration condition is specified for the area within the city limits, a stronger condition for the urban area, and a very strong condition for the downtown area.

If you want specific important areas covered, such as a division headquarters, a hospital or a theme park, each must be identified in the specification.

A typical *service area* specification might read:

"Outside buildings to a contour three miles beyond the city limits; inside residential buildings (3dB) within the city limits; inside moderate (8dB) buildings and heavy (15dB) buildings within the areas shown on the attached map."

Simulcast access considerations

A simulcast trunked radio system is perfectly capable of providing a block-buster signal to a mobile radio but still denying it access to the system. Because the user perceives this condition as simply a "dead spot," it is up to you to ensure that the vendor incorporates access guarantees and access testing into its plan.

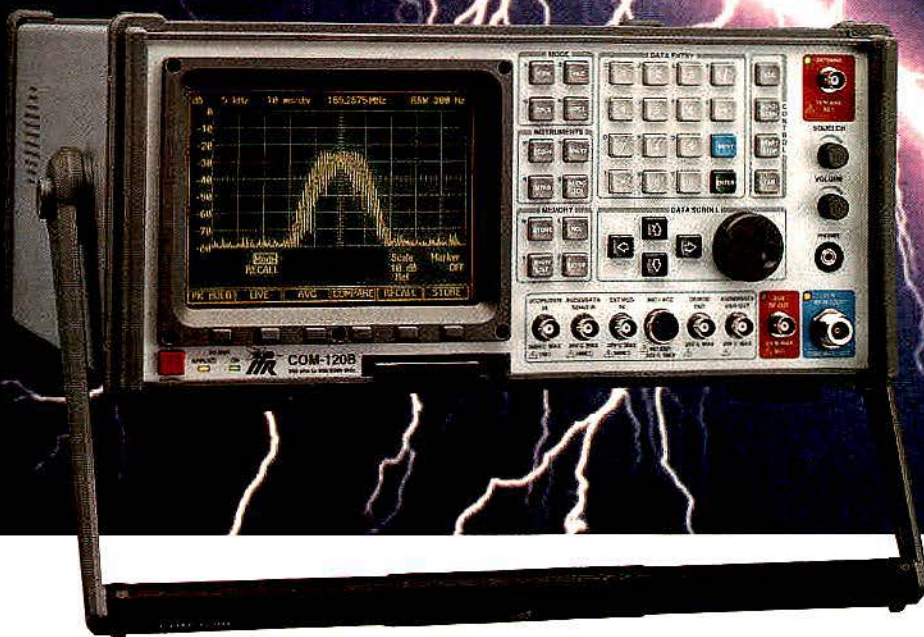
Access problems in high-signal areas

Forrest is vice president of the Communications Technology Associates division of Hayes, Seay, Mattern & Mattern, Lynchburg, VA.

Table 1—Grade of service—circuit merit figure.

CIRCUIT TYPICAL MERIT SIGNAL FIGURE LEVEL	GRADE OF CIRCUIT PERFORMANCE	VOICE FREQUENCY SIGNAL-TO-NOISE RATIO	TYPICAL RECEIVER QUIETING
1	Unusable. Presence of speech barely discernible.	Below 8dB	0 to 6dB <0.22µV
2	Readable with difficulty. Requires frequent repetition. (Non-commercial)	8 to 16dB	14dB 0.35µV
3	Readable with only a few syllables missing. Requires occasional repetition. (Commercial)	14 to 22dB	20dB 0.50µV

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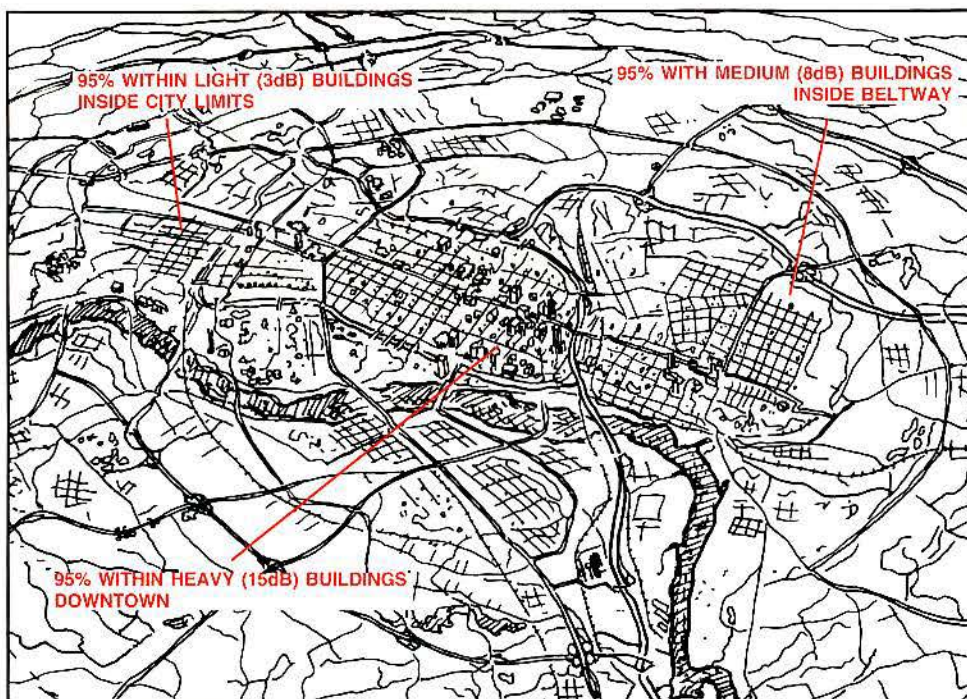


Figure 1. Define *service area* by describing where you need to talk regularly. You may want to specify different conditions associated with different service areas. For example, a major eastern city might specify "inside building coverage." One building penetration condition is specified for the area within the city limits, a stronger condition for the urban area, and a very strong condition for the downtown area.

generally are caused by asymmetrical signal delays that exceed a half-bit in duration. They mostly occur in areas where signal levels from two sites are fairly close to one another. Access can be a problem even where signal levels differ by 10dB to 15dB. The vendor has control over the phase differences at any location. Improving the situation at one location probably will make it worse at another. The design is therefore a compromise.

Access problems result from a complex interaction of signal level, multipath fading, antenna directivity, distance from each transmitter, delay inserted into the signal path, data rate and the radio firmware.

Because an access problem appears to the user to be similar to a dead spot caused by weak signal, I typically incorporate access guarantees as part of the coverage guarantee. If I am looking for 90% availability, I would state that *either* signal level or

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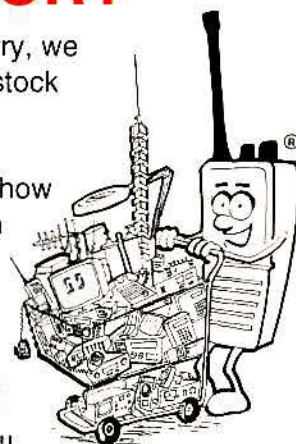
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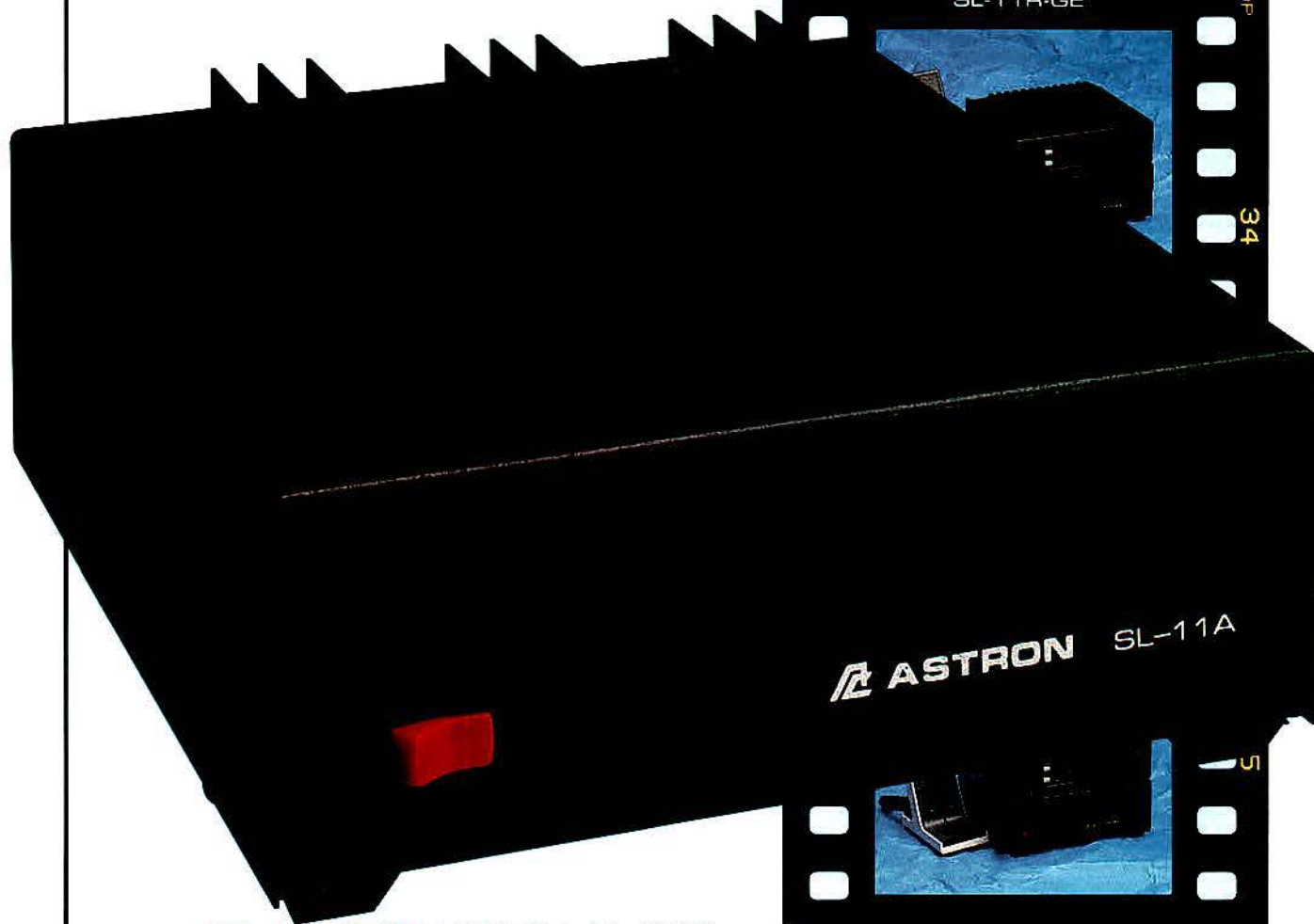
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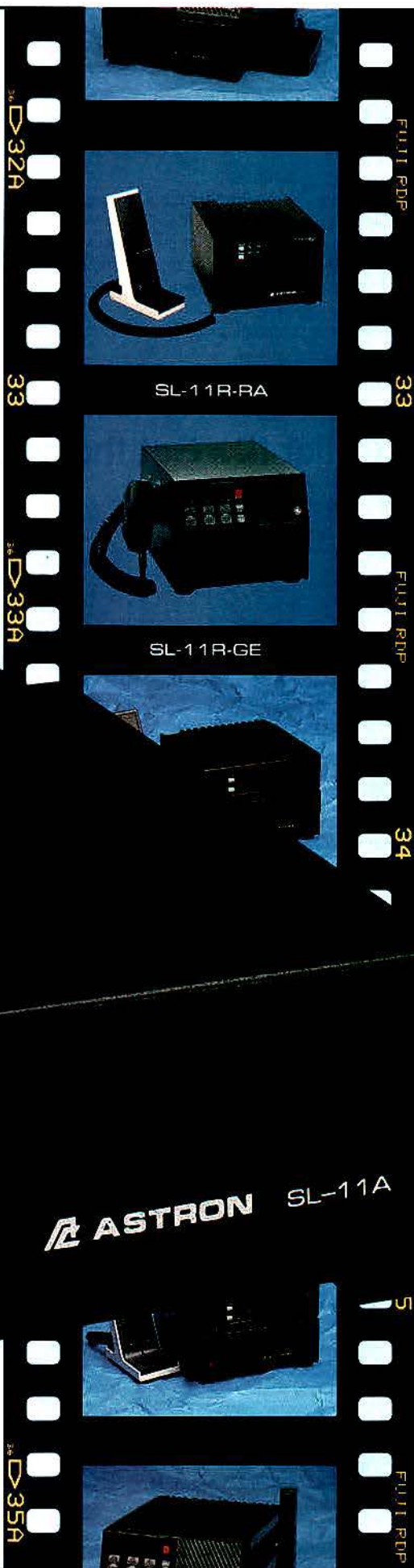
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denial of access will count as a failed test point.

Coverage guarantee

You should require that the vendor provide as part of its proposal:

- A written guarantee to provide coverage to the level you specify, specifically addressing each of the three elements.

- The general procedures that will be used to test coverage, including the method

of reducing data to a usable form.

- Maps confirming the contours within which the vendor predicts coverage.

- A general discussion of the process and the model used in predicting coverage.

The vendor should identify any areas within which it takes exception to the coverage specifications, describing the level to which coverage will be provided in those areas.

Finally, any contract with your vendor

should explicitly include the coverage guarantee. Do not drop the ball at contract time. The vendor must be made fully aware that the system will be tested against its guarantees.

Measurement process

Be practical. You are going to pay for the measurements. Do not pay for information that is only of academic interest. Some points to consider:

- Make sure the measurement process fits the specification. A "shout and holler" test will not prove the existence of a $0.5\mu V$ signal.

- Take an adequate sample size. You need at least 250 test points. I recommend no less than two points per square mile.

- The process should measure a random and evenly distributed sample across

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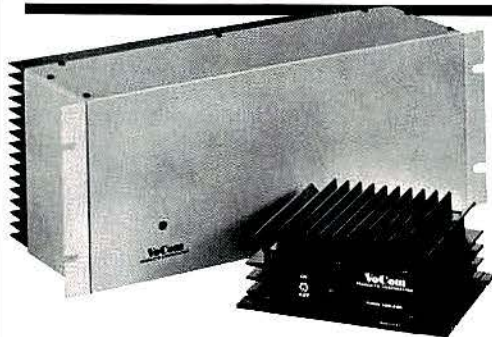


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*Make sure that you
witness the test. Do not
leave the fox to guard
the henhouse.*

the service area. Ensure that there is no bias built into the test, such as the vendor wanting to test from interstate highways, but the owner wanting to test along river bottoms.

- The process should be statistically repeatable. If 96.5% of the tests pass today, then about 96.5% of the tests should pass next Tuesday. There is no requirement that the 3.5% of the failures be in the same places.

- The procedure should be practical. Encourage the vendor to make a moving test using a vehicle. Simulate indoor tests by adding loss to the test results. Ensure that test samples are based on the *median* signal level rather than the mean or average.

- Allow the vendor to use its standard test facility. Most of these are computerized sampling devices with inherent location information, and they will do an excellent job.

- Make sure that, in your specification, the vendor is required to reduce the data and to display them in a usable form. This is the vendor's job. It will be time-consuming and lead to arguments if you do it.

Measurement and analysis setups

Figure 2 on page 32 shows a typical measurement configuration. Some points:

"YOUR BUYER'S GUIDE REPLACES THE 10 TO 20 CATALOGS WE USED TO USE. IT'S BY FAR THE BEST I'VE EVER SEEN!"

J. R. Rzucidlo

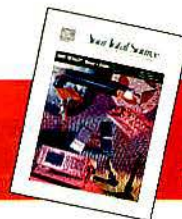
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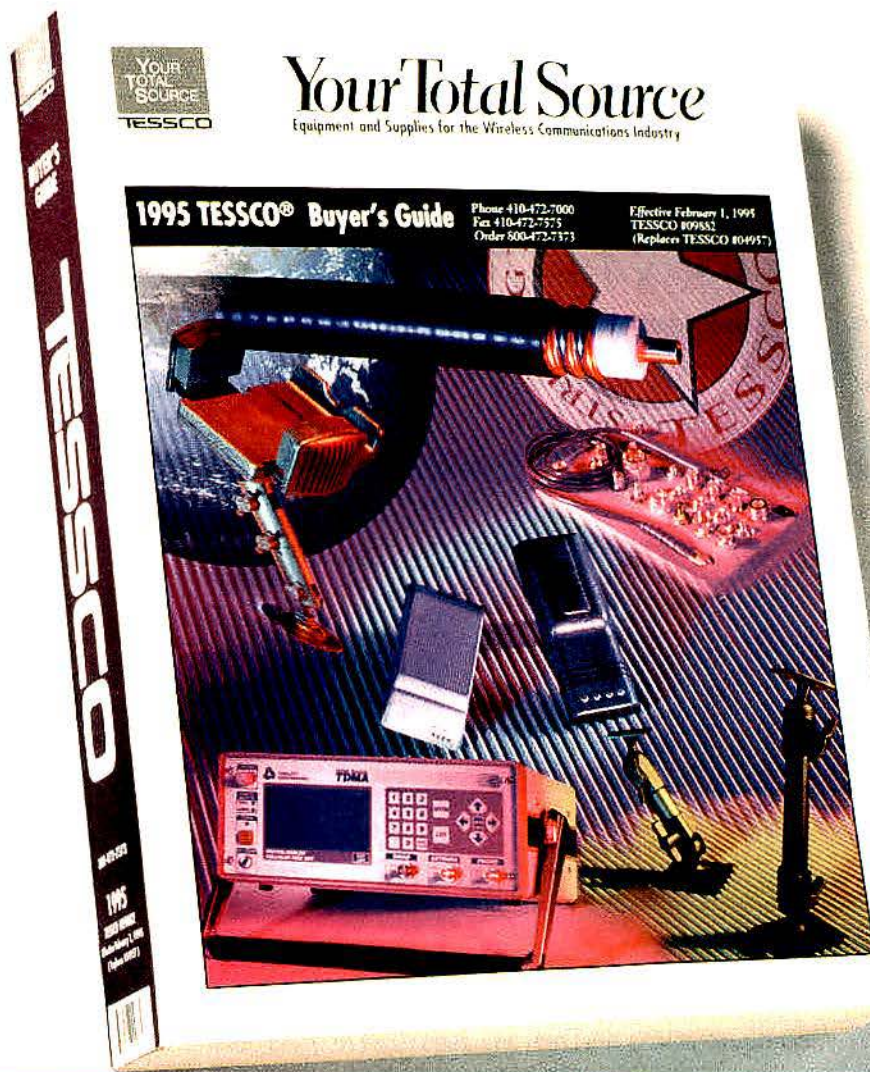


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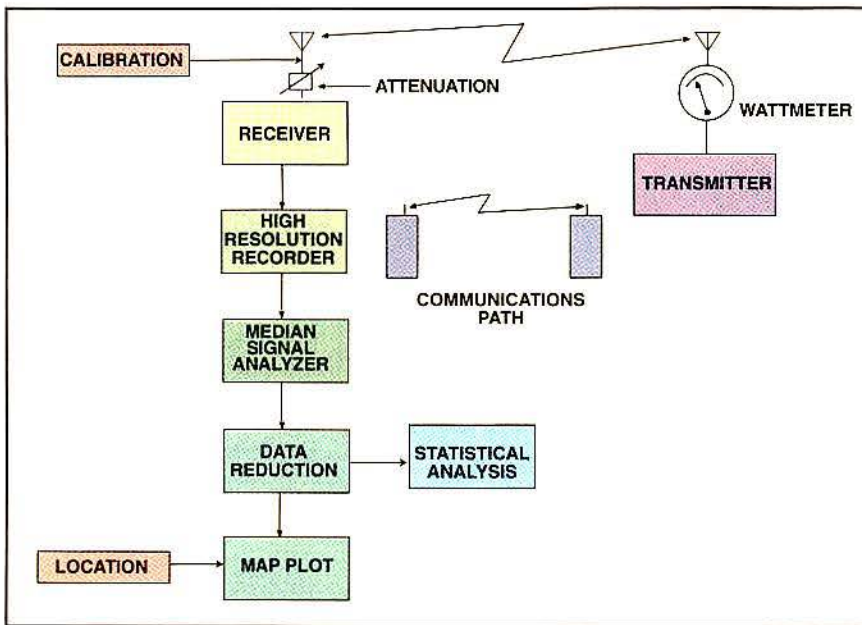


Figure 2. A typical measurement configuration.

- ☐ Tests are to be done while the vehicle is moving.
- ☐ It is preferable to have automatic data reduction.
- ☐ Test samples are to be taken over a

minimum of 40 wavelengths.

- ☐ If talk-out and talk-back are reciprocal, testing only needs to be done in one direction.
- ☐ Make sure that you witness the test.

Do not leave the fox to guard the henhouse.

Summary

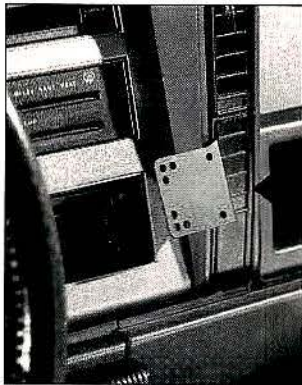
There is nothing simple about radio propagation or radio coverage specification, prediction, interpretation or proof of performance. Vendors, if left alone, will promise the world up front but will attempt to include an escape hatch in their contract. Consider using assistance from professionals who have been through the process. Remember that all elements, from the initial assessment of your needs through procurement to implementation and final testing, must effectively integrate.

This installment completes the article series. Part I was printed in the May 1995 edition. To order back issues, call 800-441-0294.

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Forrest, Robert T., "Common Radio Propagation Modes in Plain English Series," *APCO Bulletin*, May 1991, pp. 56-64; June 1991, pp. 77-78; July 1991, pp. 52-54; November 1991, pp. 46-49; April 1992, pp. 54-56; May 1992, pp. 46-47.

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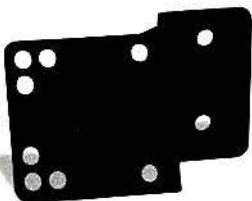


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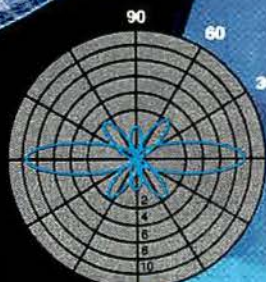
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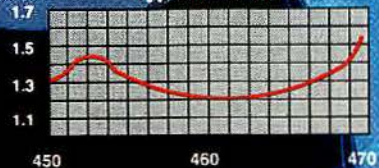
Radiation Pattern
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Servicing pagers: And you shall receiver knowledge . . .

Part 15—Details about the Bravo Plus and Bravo Express 928MHz–932MHz NRF4101 receiver boards include some tips to make testing easier and faster. As with the Bravo, the 17.9MHz IF units have critical adjustments.

By David Ludvigson

The NRF 4104 receiver board for 928MHz–932MHz Bravo Plus and Bravo Express pagers comes in two basic fla-

vors—17.9MHz IF and 45MHz IF versions. Past articles on the Bravo have dealt extensively with the frequency stability and other characteristics of these two IF blocks. (See Part 7, "Problems In Paradise," July 1994 issue.)

Basically, the 45MHz IF board is less critical of adjustment than the 17.9MHz board. This difference stems from:

Ludvigson is a technician in Houston.

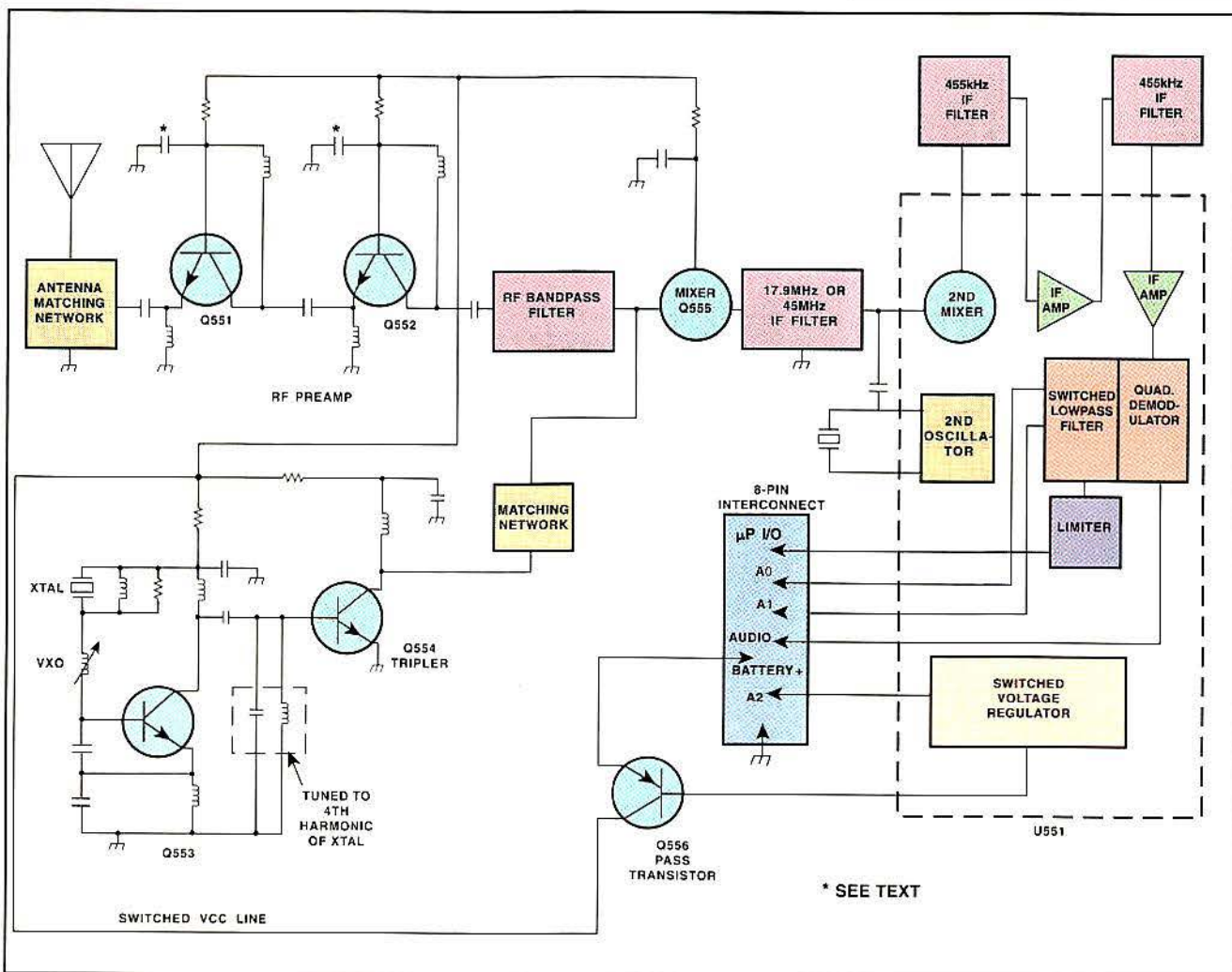


Figure 1. This block diagram represents the circuitry used in the Bravo Plus and Bravo Express receivers.



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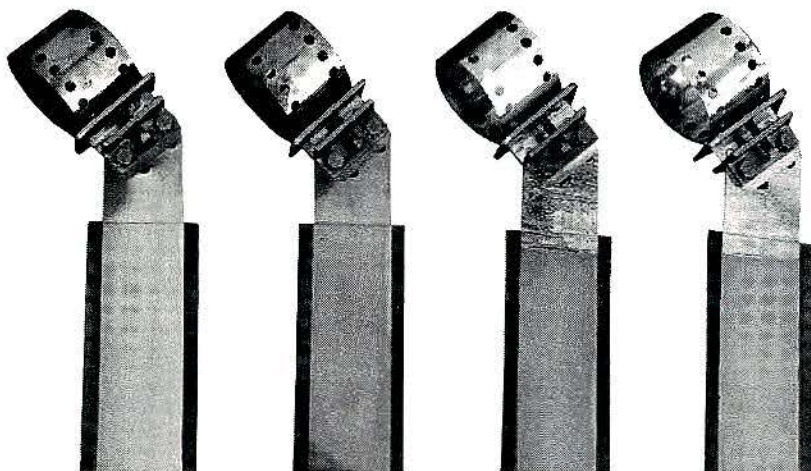
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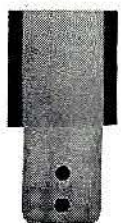


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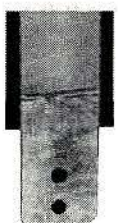
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(1) the stability of the first conversion oscillator.

(2) the bandwidth of the signal getting through the IF stage.

The service technician can expect problems with the 17.9MHz IF boards from another perspective—the only controls accessible to the technician are the first conversion oscillator tuning and the antenna matching network. The rest of the tuned circuits are either thin-film encapsulated or surface-mounted, pre-tuned networks that only a soul bent on sainthood would care to adjust!

One block diagram is sufficient to fully appreciate these receivers. (See Figure 1 on page 34.)

RF preselection is provided by a pair of transistors in common-base configuration. These two stages have been configured to provide about 12dB of gain without requiring a neutralizing network. Either of these stages, though, can get "wild" if the base bypass capacitors should open—in which case sensitivity drops off severely, or adjustment of the antenna network causes the stages to oscillate—so watch for poor solder joints!

The first conversion crystal oscillator is a Colpitts circuit with oscillation taking place between the base and emitter of Q553. Output from the collector is tuned to roughly four times the crystal frequency by means of a surface-mounted coil and capacitor. This same LC network feeds Q554, which is configured as a frequency tripler. This tripler yields an output of nearly 900MHz to the base of mixer Q555.

At Q555, a combination of the RF signal (at 931MHz, roughly) and the signal from the oscillator-multiplier stages is coupled into the base. The collector circuit contains the crystal filter, either 17.9MHz or 45MHz, and a matching network directly feeding the second mixer.

Within, U551 has a multitude of capabilities. Not only does it include a mixer, it has another crystal oscillator, a pair of 455kHz IF amplifiers, a quadrature FM detector, a switching low-pass filter, a limiter and at least two voltage regulators. It's a jungle in there!

In the Bravo, low-pass filtering is a function of a separate RC network on the logic boards. In the Bravo Plus and Bravo Express, the 4101 series receiver boards have audio filtering functions controlled by signals from the logic board that are fed into the "jungle-chip" on the receiver board. More about this later.

Getting into test mode

As with their little brother, the Bravo, the Bravo Plus and Bravo Express spend much of their time turned off. The battery

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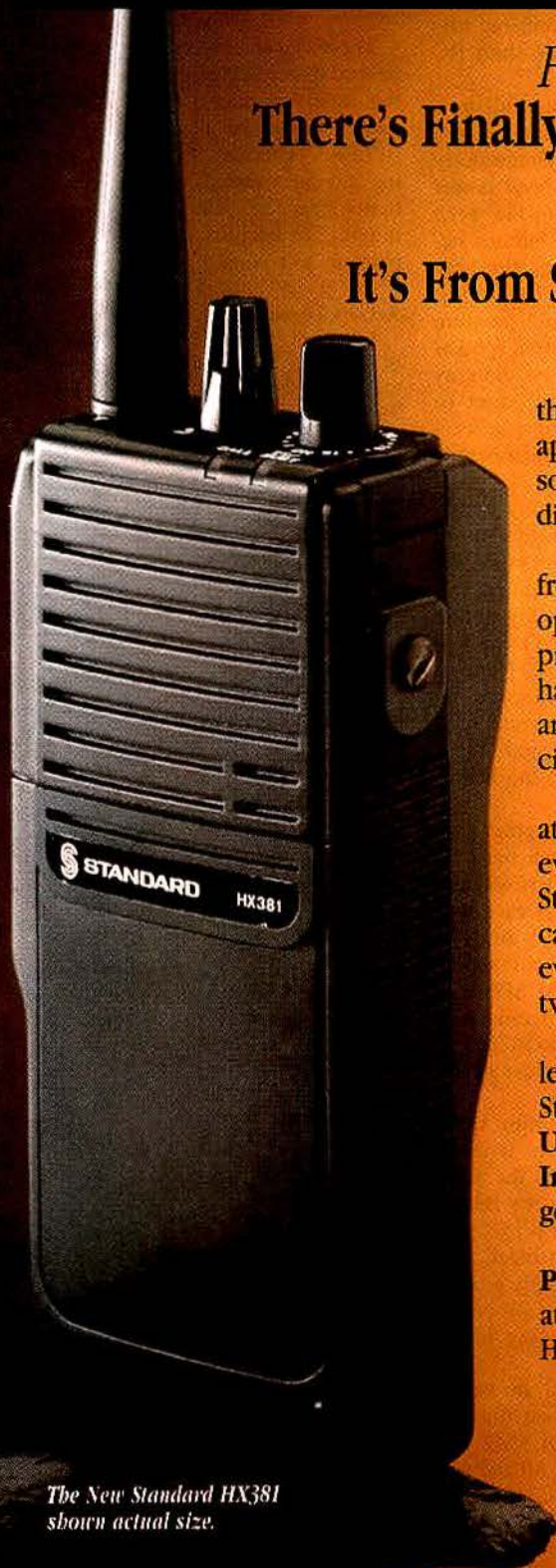
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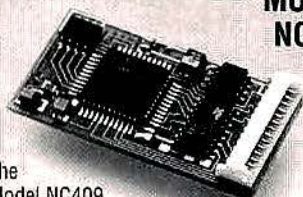
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saver literally gates the entire 1V line to the RF preamp, first injection oscillator-multiplier and mixer stages simultaneously. At first glance, one would expect this gating to cause frequency instability as the oscillator is being turned from *off* to *on*. The single saving grace for this method lies in the fact that the switched voltage is well-regulated, and the dc decoupling networks to each stage have very short RC time constants.

Placing the Bravo Plus into full-time receive mode requires depressing the two buttons beneath the display simultaneously while bringing the *off-mem-beep* power switch from *off* all the way to the *beep* position. Quickly release the buttons beneath the display, and depress the gray (READ) button momentarily. This procedure sets the pager into sound pressure level (SPL) mode, and the internal speaker will emit a steady tone. Depress the gray button again to advance the pager to MODE 1. In this mode, the pager is serviceable as far as the receiver alignment is concerned.

Another depression of the gray button sets the pager to MODE 2. In this mode, the decoder gives a single chirp when the proper capcode has been transmitted.

Another depression of the gray button reveals hexadecimal information as to how the pager has been programmed. None of this information reveals the capcode, by the way. The capcode must be read with the BRAVOPPS software discussed in Part 13, "Essential Differences," in the February 1995 issue.

When placing the Bravo Express into test mode, a different approach must be taken. Turn the Express off, then, sequentially, from right to left, depress each button beneath the display, and wait. The word POCSAG with a numeral will appear in the window. If you want an SPL test, depress the center switch; otherwise the pager is set only to the test mode. To get out of test mode, turn the Express on by depressing the left button.

There are other ways of turning these pagers into full-time receivers without constantly lifting them out of the RTL 1005 radiation test fixture. For the Bravo, you could solder a 10K resistor across pins 1 and 8 of the interconnection block. For the Bravo Plus and Express, simply ground line A2 (this is easily traced to a test point) coming from the interconnecting block between the circuit boards.

It was mentioned earlier that the Bravo Plus and Express use a switched filter to define the bandpass of the POCSAG signal. The filter connects to lines A0 and A1, again available at the interconnecting block. A bit of experimenting shows that

when the pager is in normal operating mode (capable of decoding an on-the-air signal), programming different POCSAG rates into the pager (at the computer) cause lines A0 and A1 to respond differently.

POCSAG 512 A0 goes low, A1 goes high
POCSAG 1200 A0 goes high, A1 goes low

These changes occur in response to the strobed battery-saver signal at Line A2 and the received data stream. It will help greatly if you use the IFFER ("Build An IFFER," February 1994 issue) when trying this for yourself, because you can actually hear the voltage transitions while moving an oscilloscope probe from test point to test point.

Acknowledgement

I would like to thank the management and staff of JJ Sounds & Communications, South Houston, TX, for their help with this project. Tel: 713-944-1813.

Pager servicing series

Part 1: "Build a Shielded Room," January 1994. (All pagers.)

Part 2: "Build An IFFER," February 1994. (Bravo, Bravo Plus, Bravo Express.)

Part 3: "Frequencies, Coding Formats, March 1994. (Bravo.)

Part 4: "From Bench To Programmer," April 1994. (Bravo.)

Part 5: "The Receivers," May 1994. (Bravo.)

Part 6: "Elegant Simplicity," June 1994. (Bravo.)

Part 7: "Problems In Paradise," July 1994. (Bravo.)

Part 8: "406MHz-512MHz Receivers," August 1994. (Bravo.)

Part 9: "150MHz Receivers," September 1994. (Bravo.)

Part 10: "Tales Crystal Filters Tell . . .," October 1994. (Bravo, Bravo Plus, Bravo Express.)

Part 11: "Microprocessor Board," November 1994. (Bravo.)

Part 12: "Headaches (and some aspirin)," January 1995. (Bravo.)

Part 13: "Mixed Signals," February 1995. (Bravo.)

Part 14: "Essential Differences," April 1995. (Bravo Plus, Bravo Express.)

Part 15: "And You Shall Receive Knowledge . . .," June 1995. (Bravo Plus, Bravo Express.)

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How to select antennas for mobile radio systems

The antenna is important to all mobile radio systems. Often, it is more cost-effective to improve the antenna for better coverage than to improve receiving system sensitivity or to increase transmitter power.

By Roald Steen

The right antenna is an important part of a good two-way radio system.

The antenna determines how RF power from the transmitter is to be transmitted. In the receive mode, the antenna determines how sensitive the radio system will be to the surrounding landscape. The correct antenna minimizes noise and reduces the radio system's interference with other radio services.

An antenna is said to have *gain* if it concentrates its signal toward certain directions. Gain is a comparative value. Antenna gain can be compared either to a dipole or to an isotropic antenna. Whereas the dipole is a real antenna that sees much practical use, the isotropic antenna is a theoretical model.

An isotropic antenna transmits equally well in all directions. Its radiation pattern is spherical. To convert antenna gain compared to an isotropic antenna (expressed in dBi units), subtract about 2dB to estimate the same antenna's gain compared to a dipole (expressed in dBd units).

An antenna with gain in one or more directions attenuates the signal in other directions. For example, an omnidirectional antenna with gain concentrates its emission toward the horizon, and the emission is attenuated in higher or lower directions.

Other antennas with more pronounced directivity toward one part of the horizon have a front-to-back ratio. This ratio is important because it is often important to have minimal signal emission in the direction opposite to the desired direction.

Steen is an electronics instructor and free-lance writer. He has worked as a two-way radio technician, and he lives in Woodbury, MN.

It would be ideal to illustrate an antenna's emission pattern as a three-dimensional image. Because this is impossible on paper, an emission pattern is normally presented in two diagrams, representing the horizontal and the vertical emission patterns.

The emission pattern of an antenna close to the ground (as measured in wavelengths for the operating frequency) is affected by ground conditions.

Some antennas have an artificial grounding system of radial poles. Others—

If a receiving and a transmitting antenna have opposite polarizations, the signal between them is extremely attenuated.

a vertical quarterwave antenna, for example—only work well when mounted on a good ground plane.

Antenna polarization is important. If a receiving and a transmitting antenna have opposite polarizations, the signal between them is extremely attenuated. Choosing polarization for mobile radio service is easy; almost all antennas are designed for vertical polarization. A vertical whip antenna and a vertical dipole have vertical polarization. Similarly, more complicated antennas, such as yagis and parabolic reflectors, can be vertically polarized by orienting the yagi elements or the reflector feed element vertically.

An antenna must present a good match to the transmission line. The 50Ω coaxial transmission line has become a standard in

the mobile radio industry; therefore, almost all mobile antennas present a 50Ω load at the operating frequency. A vertical quarterwave antenna mounted on a good ground plane has an impedance near 50Ω. For most other antenna types, some sort of matching unit must be built into the antenna to produce the 50Ω impedance at the feedpoint.

An antenna can be constructed for several bands or for only one band. In mobile radio service, one rarely needs antennas that will operate on more than one band, which makes antenna matching simple. Antennas that have to operate on more than one band are more difficult to match; the resulting impedance for each band is a compromise and may not be exactly 50Ω.

An antenna is exposed to wind and weather, so it must be weatherproof and strong. Its mount must be strong to prevent loosening during strong winds.

Lightning protection must be incorporated into many antennas; thus, many antennas are designed with a dc path to ground. To be effective, there must be good continuity to ground from the antenna mount. In tower-mounted antennas, this problem is often solved by grounding the entire tower.

The antenna, and the point where the antenna is connected to the coaxial cable, must be weatherproof. For mobile antennas, it is important that the antenna mounting hole also be weatherproofed.

Ease of installation is also important. For a tower-mounted antenna, it must be possible to mount the antenna while working from a difficult working position. For vehicular antennas, aesthetics are important. Many vehicle owners do not want holes drilled in their vehicles, so they insist upon the through-glass type of antenna.

For vehicle antennas, an omnidirectional emission pattern is almost always preferred. The quarterwave whip antenna has an omnidirectional emission pattern. The

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$\frac{3}{8}$ -wave whip antenna has a gain of about 3dB compared to the quarterwave whip and concentrates the emission toward the horizon. There are also vehicular collinear antennas with gain.

Similar antennas are available with through-glass mounting. These antennas do not have a good ground plane, and may not provide as efficient an emission pattern as an antenna mounted in the middle of a metal roof.

Some vehicles require disguised antennas, such as undercover or unmarked police cars. Some disguised antennas look like broadcast antennas. One design uses the car body as an antenna, thanks to an appropriate impedance-matching unit. Other antenna accessories are available to allow using a broadcast antenna as a combined broadcast and two-way radio antenna.

Vehicle antennas that display directiv-

ity are little used in mobile radio service. Some CB antenna systems use two matched verticals to produce a figure-eight emission pattern with directivity toward the front and the back of the vehicle. Similar systems have seen little use in commercial or public safety mobile radio service.

Base stations and repeaters may need a variety of antennas, depending on the location, the desired coverage area and the antenna height.

Some repeaters at the outskirts of a desired coverage area may need an antenna with an emission pattern that covers 180° or less of the horizon. Several antennas provide this type of emission pattern. For example, an antenna with a flat reflector covers an area about 180° wide in front of it. Antennas with corner reflectors have coverage patterns as narrow as 90°.

Antennas with such reflectors can be made with multiple elements to concentrate the emission toward the horizon in the vertical plane as well as concentrating the emission toward a part of the horizon in the horizontal plane.

Some antennas are mounted too high above the desired coverage area. If the signal needs to reach the ground nearby, it may be necessary to use an antenna with beam tilt that directs the signal below the horizon. In other cases, a single vertical dipole may suffice. The dipole does not concentrate the emission or reception patterns toward the horizon, so it may receive well from locations near the antenna site but not as well from great distances.

To reach a small, specific sector of the horizon from a base station or repeater station, a high-gain antenna, such as a yagi beam, may be a good choice. The yagi beam uses parasitic elements to obtain gain. Parasitic elements are either reflectors or directors, and they are not electrically connected with the driven element. Instead, they are coupled with the driven element by the RF field emitted by the driven element. The driven element, usually a dipole, is the part of the antenna connected to the coaxial cable feedline.

Other types of reflectors can be used to obtain a sharp signal beam. An example is the parabolic reflector, or reflectors that are shaped like a parabolic half-cylinder.

A figure-eight emission pattern may, for example, be desirable for a base station or repeater intended to cover a narrow strip along a highway or a railroad. Among the antennas that provide this type of emission patterns are antennas that use two phased driven elements.

Several antenna types display a nearly omnidirectional emission pattern with gain. One popular example of this is the

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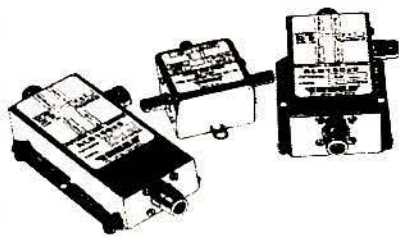
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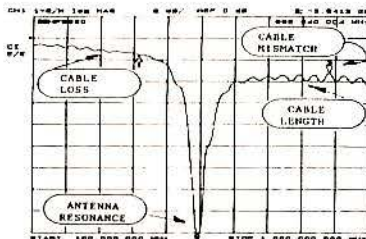
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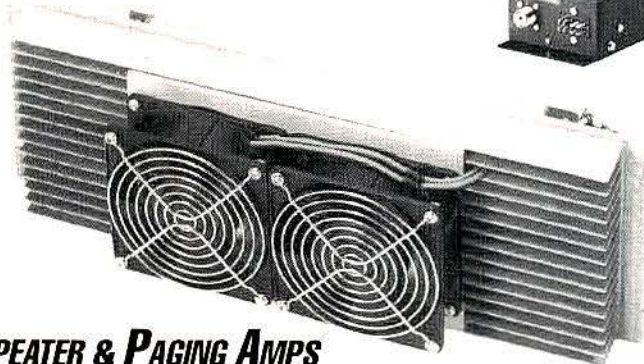
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collinear antenna, which uses parasitic elements that are mounted above a driven element to add gain.

Other omnidirectional antennas with gain are based on the folded dipole design, a design that allows dipoles to be made with dc-grounded elements. These antennas, also called *multibay antennas*, use several folded dipoles mounted above each other.

Folded dipole antennas can be given directivity. When all the folded dipoles are mounted on one side of the antenna, it has gain in that direction. When they are mounted with two sets of folded dipoles 180° apart, they tend to have a bidirectional or an elliptical emission pattern.

The antenna mounting location on a tower influences its directivity. An omnidirectional antenna can be expected to have an omnidirectional emission pattern only when it is mounted on the top by itself. Otherwise, the tower influences the emission pattern. The tower acts as a reflector, reducing the emission pattern in the direction towards the tower while enhancing directivity in other directions.

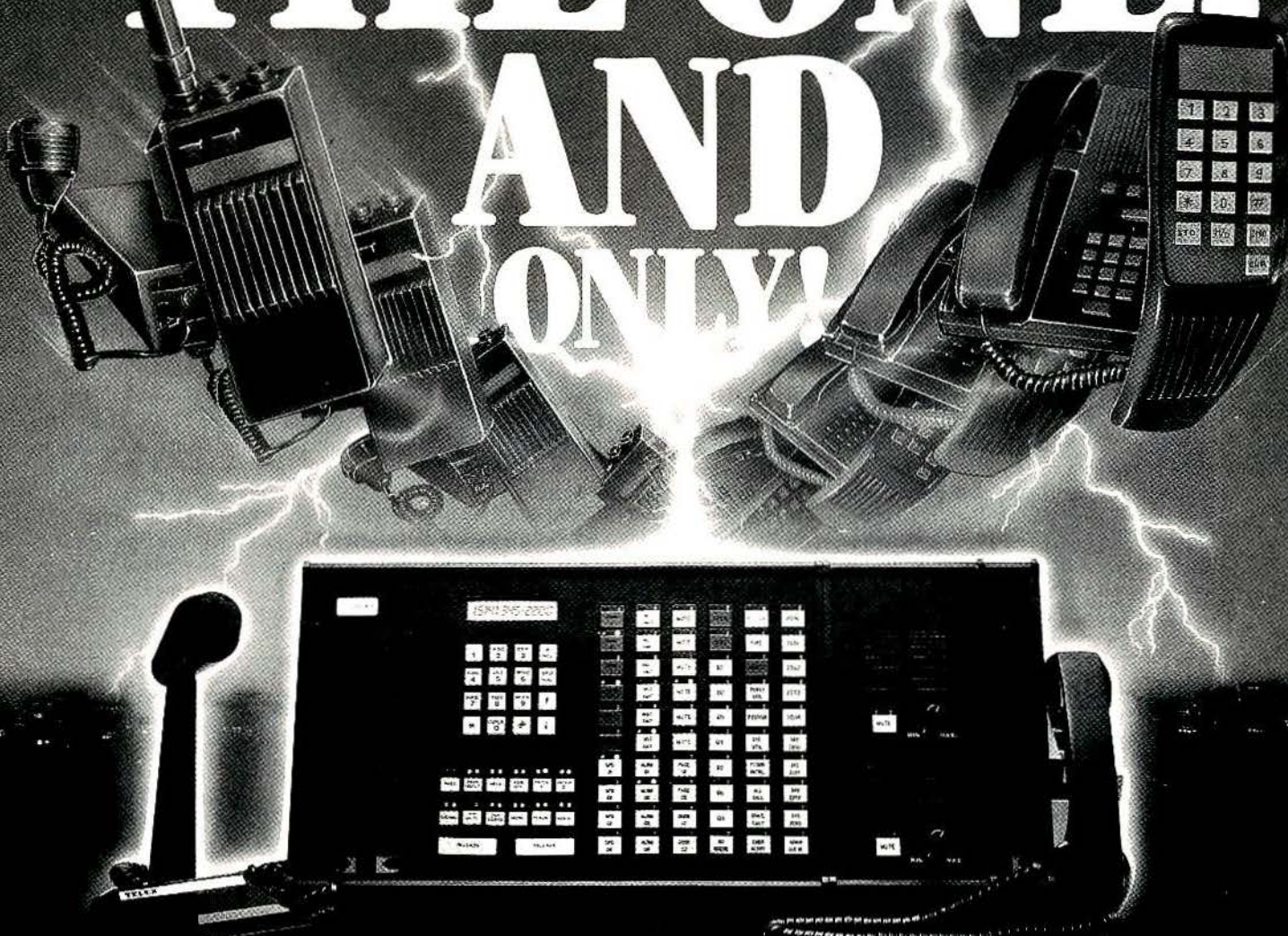
This problem of a side-mounted omnidirectional antenna taking on unwanted directional characteristics can be solved by mounting several antennas almost in a circle around the tower. This solution also concentrates the emission more toward the horizon compared to the vertical pattern from a single omnidirectional antenna of the same type.

Some tall buildings tend to have many antennas mounted in roughly the same horizontal plane. This configuration, especially with antennas operating at similar frequencies, can create interference and unexpected directivity. For example, an omnidirectional antenna may display a great deal of gain in some directions of the horizon and greatly attenuated emission in other directions. The building and its roof may create "shadows" in the emission pattern. These problems are lessened when the antenna has directivity toward a sector of the horizon, provided that it is mounted on the proper side of the building to cover that sector.

The antenna is important to all mobile radio systems. Often, it is more cost-effective to improve the antenna for better coverage than to improve receiving system sensitivity or to increase transmitter power.



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(continued from page 8)

In polar form, the expression for this impedance would be 50Ω at an angle of 53.1° . The VSWR at this point is 3:1. One-eighth wavelength down the line toward the generator, the impedance is a pure resistance of 150Ω , or 150Ω at an angle of 0° . The impedance at other points along the line is as indicated at the various points. If this line is a lossless line, the VSWR will be the same (3:1) at any point along the line, although the impedance changes.

To reduce the mismatch at the generator output, a simple attenuator pad can be placed between the generator output and the load. In Figure 3 on page 8, a 6dB pi-pad is placed between the load impedance ($30 + j40$ ohms) and the generator. The pi-pad is represented by R_1 , R_2 and R_3 in Figure 3A. The complex load impedance is represented by R_L and X_L .

The equivalent impedance presented to the signal generator by the combination of the 6dB pi-pad and the complex load impedance is derived by the process of evolution shown in Figures 3A to 3H.

In Figure 3B, the complex series im-

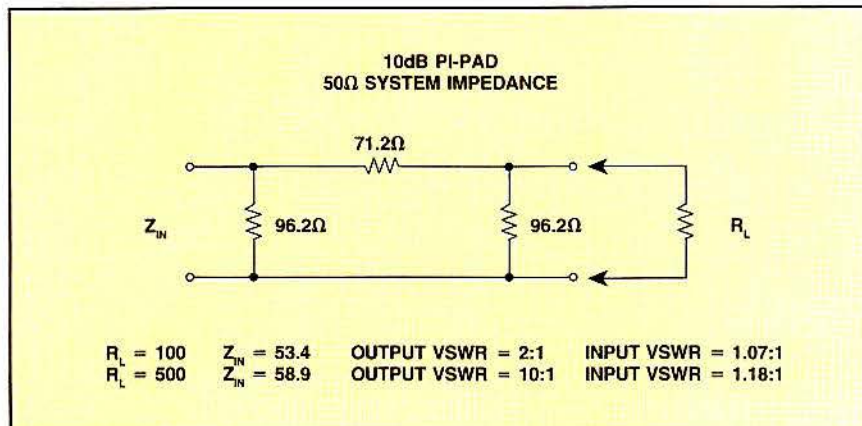


Figure 4. This shows how a 10dB pad would reduce the VSWR for a load of 100Ω or 500Ω. The 100Ω load would normally cause a VSWR of 2:1, but the 10dB pad reduces the VSWR to 1.07:1. The 500Ω load would cause a VSWR of 10:1, but the 10dB pad reduces it to 1.18:1 at the input.

pedance is converted to the equivalent parallel impedance. Then the parallel combination of R_L and R_3 is replaced by a single resistor, R_4 , shown in Figure 3C.

Next, the impedance consisting of R_4 and X_L in Figure 3C is converted to the equivalent series impedance. X_L and R_5 shown in Figure 3D. Then the series combination of R_5 and R_2 are replaced by a single resistor, R_6 , in Figure 3E.

The series combination of X_L and R_6 in Figure 3E are replaced by the equivalent parallel combination R_7 and X_L in Figure 3F. Then the combination of R_1 and R_7 in parallel in Figure 3F is replaced by a single resistor, R_8 , shown in Figure 3G. Finally, the parallel impedance consisting of R_8 and X_L is replaced by the equivalent series impedance X_L and R_L shown in Figure 3H.

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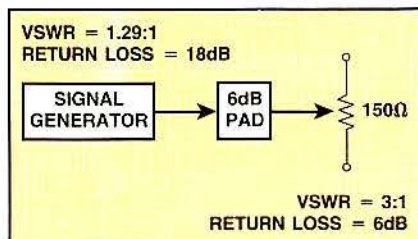


Figure 5. Here, a signal generator is connected to a 150Ω load through a 6dB pad. The VSWR at the load is 3:1 (return loss is 6dB) but is reduced through the pad to a VSWR of 1.29:1 (return loss = 18dB) at the generator output.

The final impedance represented by X_L and R_L in Figure 3H is $48.7 + j12.4$ ohms. In polar form, this is 50.3Ω at an angle of 14.3° . The VSWR at the input to the pi-pad would then be 1.29:1. So the 6dB pi-pad has reduced the load VSWR from 3:1 to a VSWR of 1.29:1 at the generator output.

The greater the attenuation of the pad, the greater will be the reduction of the VSWR at the generator output. For example, Figure 4 on page 46 shows a 10dB pi-pad. Notice how the VSWR at the input to the pad ranges from 1.07:1 to 1.18:1 for a VSWR range of 2:1 to 10:1 at the output. Thus, the

pad smoothes the impedance variations between the pad output and pad input.

Return loss

If the impedance mismatch were to be represented in terms of return loss, the return loss for a VSWR of 3:1 would be about 6dB.

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{(30 + j40) - 50}{(30 + j40) + 50} = \frac{-20 + j40}{80 + j40} = \frac{20(-1 + j2)}{20(4 + j2)} = \frac{-1 + j2}{4 + j2};$$

$$\frac{(-1 + j2)(4 - j2)}{(4 + j2)(4 - j2)} = \frac{-4 + j8 + j2 - j^2 4}{16 + j8 - j8 - j^2 4} = \frac{-4 + j10 + 4}{16 + 4} = \frac{j10}{20} = j0.5;$$

$$\Gamma = 0 + j0.5$$

$$\Gamma = \sqrt{0^2 + 0.5^2} = \sqrt{0.5^2} = 0.5$$

$$\text{VSWR} = \frac{1 + \Gamma}{1 - \Gamma} = \frac{1 + 0.5}{1 - 0.5} = \frac{1.5}{0.5} = 3$$

Figure 5 to the left shows a signal generator connected to a 150Ω resistive load through a 6dB pad. Assuming no losses in the connecting lines, the return loss at the output of the 6dB pad is 6dB. The return loss at the input to the 6dB pad (signal generator output) is 18dB. This pattern of loss can be generalized into the following

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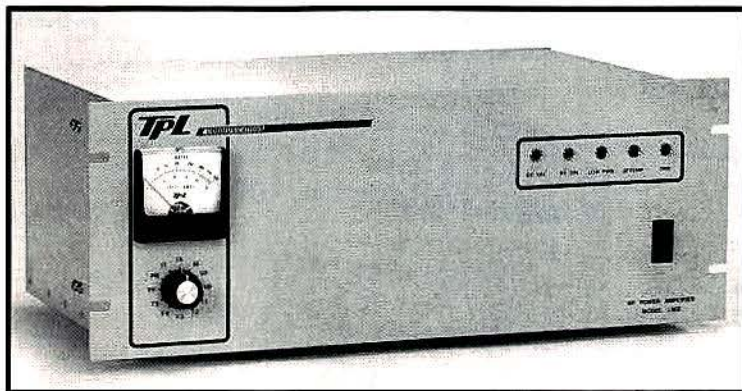
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statement: The return loss at the input to a pad is equal to the return loss at the output of the pad plus twice the attenuation of the pad. In this case, the return loss at the input to the pad is $6 + 2(6) = 18\text{dB}$.

Calculating VSWR

It is simple to calculate the VSWR when only a pure load resistance is involved. However, when the load impedance contains reactance, it is not quite so simple. To find the VSWR, we first need to know the reflection coefficient for a given complex impedance. (See box on page 48.) The reflection coefficient is represented by the Greek letter Γ . Z_L represents the load impedance in complex form, and Z_0 represents the system impedance (50Ω in our case). The equation is simplified by factoring and multiplying both the numerator and the denominator by the conjugate of the denominator. Then the equation is reduced to $\Gamma = j0.5$, or in complex form, $0 + j0.5$.

Next, Γ is found by finding the square root of the sum of the squares of the real and imaginary parts. Thus, $\Gamma = 0.5$. Substituting Γ into the formula for VSWR yields a VSWR of 3:1.

Summing up

As stated, the greater the pad attenuation, the better the match at the generator (pad input). Figure 6 to the right shows how various pads reduce the input VSWR with wide variations in output VSWR. Although pads can be built from ordinary resistors, the result may not be usable at higher frequencies. Pads used at higher frequencies are made of specially constructed resistors. The examples given here are for theoretically perfect pads. Practical pads will not deliver the ideal results. Even so, padding certainly helps to minimize the effects of impedance mismatches and measurement errors that might otherwise result.

An excellent aid in calculating VSWR from complex impedance and other transmission line calculations is the *Transmission Line Calculator*. It was invented by the late inventor of the Smith Chart, Phillip H. Smith. It is available from Analog Instruments, P.O. Box 808, New Providence, NJ 07974. Phone/fax (908) 464-4214.

A program for determining the resistance for various pads (e.g., L-pad T-pad, pi-pad and H-pad) is available from the author for \$10 plus \$2.50 for shipping and handling. A program for calculating SWR, including complex impedance, is available for \$10 plus \$2.50 for shipping and handling. Both are available on single

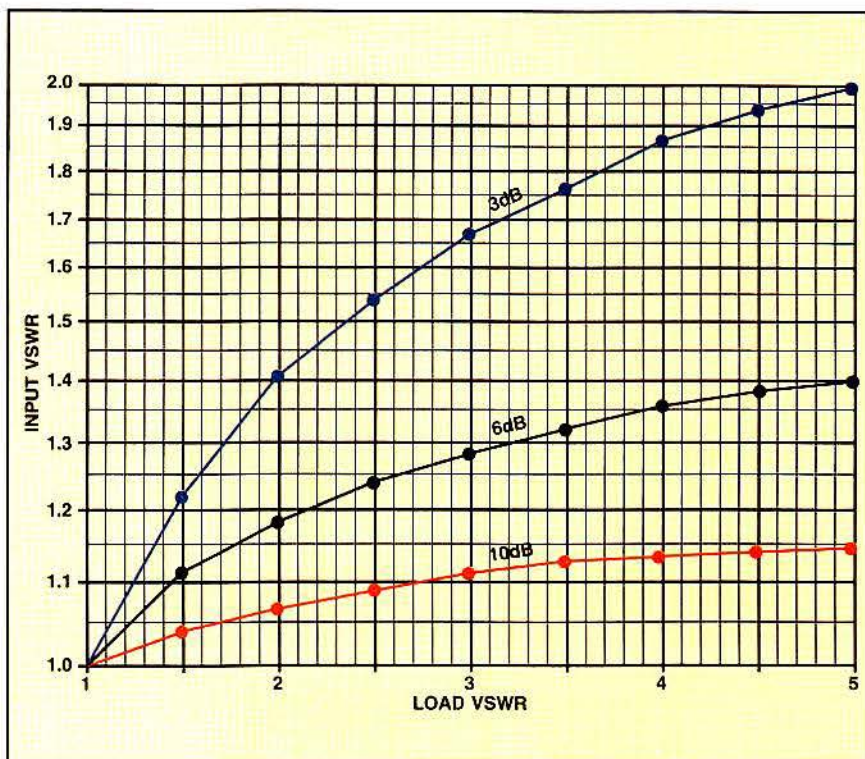


Figure 6. This graph shows how pads of 3dB, 6dB and 10dB reduce the VSWR. Note that the higher the loss of the pad, the greater the reduction in VSWR.

diskette for \$15 plus \$2.50 for shipping and handling. The programs run under MS-DOS on an IBM-compatible PC. Specify 3.5" or 5.25" floppy diskette.

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power, return loss and VSWR is also available from the author for \$5 plus \$1.50 for shipping and handling.

You may write the author at 204 Tanglewyde Drive, Spartanburg, SC 29301-2949. Stay tuned!

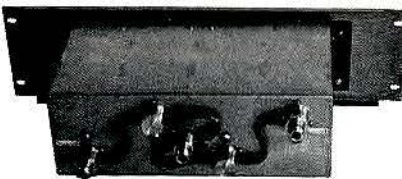


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Sharecropping on the spectrum plantation

By Robert H. Schwaninger Jr.

You can almost hear banjo music banging out an antebellum rhythm as "Colonel" Hundt considers his next auction. Each time another field of spectrum is put on the block, another spectrum plantation is

formed, and the industry more and more resembles a plantation economy.

The high-and-mighty gentlemen are sitting up in the big house on the hill (Capitol Hill, that is, son) having a constant cotillion with every lobbyist from every large telecommunications concern in America. Sipping fine brandy and talking about bet-



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ter days when a monopoly was something to be proud of, they discuss the rabble that keeps itching to undo their plans.

"You know, Senator, there's no reason why we can't just sell off the spectrum, one piece at a time. Hell, my client'd buy up quite a bit. Make a pretty penny for the treasury and the public would get all of those new fangled services to boot!"

"That's fine, sir, but what about all of the entrepreneurs and independent businessmen operating on that spectrum now?" responds the Senator. "We mustn't forget them now that election time is a-comin'."

"Don't worry, Senator," the lobbyist replies. "We'll give them all fine jobs selling our products and services. We'll take real good care of them." With a shared chuckle, the brandy sniffers are clinked together, and another deal is struck.

Each time these deals are made, every independent operator is pushed one step closer to the status of sharecropper. If unchecked, huge companies will carve out vast reserves of spectrum and licenses until the only way an honest, small businessman will be able to make a living is as a reseller, installation agent or maintenance arm of some large company.

Sold for taxes

With the bang of an auction gavel, the FCC allows the highest bidder to operate on spectrum across a large geographic area and to produce whatever services it deems appropriate. The smaller operators are supposed to

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Schwaninger, MRT's regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.

make room for the largest operators through forced frequency migration. Your small business is being "sold for taxes."

Some operators will be allowed to work the fields for the plantation owners, reselling service under onerous contracts, selling equipment too expensive for their clients' needs and generally becoming second-class workers—toiling to install and maintain the master's goods.

This will produce "cash flow," which has replaced profit as the chief indicator that financial analysts use to measure the success of telecommunications companies.

Independent businessperson

A few spectrum plantations wouldn't be so bad if the FCC and Congress recognized the benefits in keeping alive the spirit of the independent businessperson. Some of this industry's best ideas came from small, aggressive companies motivated by the vast opportunities in telecommunications.

The old "forty acres and a mule" idea created and sustained independence, initiative and drive. It rewarded industry and punished sloth. The outcome would have been different if the land and mule had to be purchased at auction.

In dollar terms, the latest personal communications services (PCS) auction is a resounding success. But what happens when this industry becomes the exclusive reserve of a handful of wealthy companies and conglomerates? What happens to those customers whose demographic profile does not fit the norm for large-scale operations in their region? What happens to the vigor of the thousands of two-way radio shops, local paging companies, independent specialized mobile radio (SMR) system operators and private carriers forced to compete at auction with the largest entities?

Small business champion

The opportunities presently enjoyed by small business should be protected and extended. The fierce crucible of energy that burns in the independent radio community should not be doused with dollars and forged into a malleable mediocrity that bends to the whims of the largest carriers.

Being wealthy is advantage enough for any business. It presents opportunities and business strategies far outside the reach of the small entrepreneur. Additional freedom from the effects of true competition is unnecessary and unhealthy.

I, for one, want someone or some group to step forward to represent the interests of the small business community. Such an effort would lend much needed balance to the discussions that are presently under way and that threaten to turn the independent operator into little more than a share-

cropper. If you have that vision, write to me, and I'll help you get started.

It is time to defend your business and rights as a licensee before spectrum "refarming" becomes another excuse for more spectrum plantations.

* * *

My thanks to Walter Rausch, Mark Cobbeldick and Larry Smith, who pointed out that Railroad Radio Service frequencies are, indeed, shared with many other eligibles. It's good to be told I'm wrong

sometimes. It keeps my hat size in check.

* * *

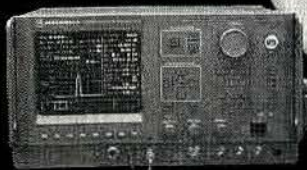
Editor's note: The acronym "LMS," meaning "location monitoring service" in Robert's April column, was spelled out as "lousy mobile service" by us just to be silly in the draft version (tee hee). Unfortunately, we didn't correct it to read as Robert wrote it before the issue was printed (Omgod!). Robert noticed. Maybe you did, too. Sorry.



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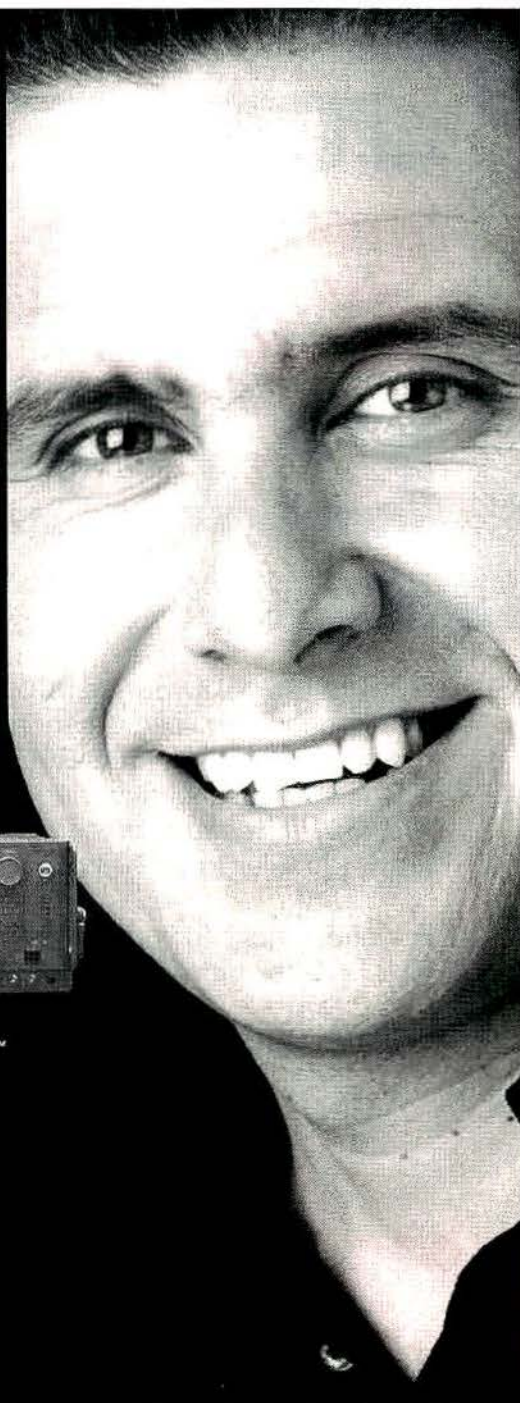


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Motorola enters wireless software market with internal, partnered mobile applications

Motorola has entered the wireless communications software business, "the fastest-growing segment for mobile data vertical markets," said Bill Blandford, the company's operations manager for its RadioWare Software Solutions business division. The software, provided by Motorola's Land Mobile Products Sector, Schaumburg, IL, will be created by allied

developers and by Motorola itself.

Motorola's strategic software alliance program unites third-party software solution providers under the RadioWare banner to supplement Motorola's internally developed products. Software applications from allied developers include automatic vehicle location (AVL), computer-aided dispatch (CAD), message switching, mo-

bile terminal messaging, records management and report writing.

Alliance partners to date include: OCS Technologies, Pleasanton, CA; Westinghouse Electric, Baltimore; Tusk, Palm Beach Gardens, CA; and Impact Solutions, San Diego. Initial offerings provided by these alliance partners target the mobile computing and public safety markets, particularly law enforcement.

RadioWare programs will use advanced object-oriented technologies and a service creation environment for wireless networks, said Blandford.

"RadioWare will combine our strategic alliances' software packages with internally developed software, like MagicPipe, to provide complex vertical market software solutions for mobile workers," he said. Stated goals for the RadioWare business are to integrate wireless networks and to maximize scarce radio spectrum availability by using technologies such as compression and net change.

One of the first internally developed releases from the RadioWare software line is WaveSoft-Fire. The program allows firefighters to access maps, building surveys or inventories and hazmat safety data sheets from a laptop computer while en route to a fire scene.

Motorola will offer both pre-sale and post-sale software support for the new line, including system integration, 800-number hot lines, ongoing maintenance programs and software updates.

Third frequency application window open for filing

The New England Planning Committee (FCC Region 19) has announced the opening of a new frequency application window. Region 19 includes Maine, New Hampshire, Vermont, Rhode Island, Massachusetts and in Connecticut the counties of New London, Windham, Tolland and Hartford.

Applications for a third window filing for the 821MHz-824MHz/866MHz-869MHz band must be post marked after July 31, 1995 and before September 1, 1995.

For further information and an application package, contact James Blesso, Committee Chairman, New England Planning Committee, C/O Office of Statewide Emergency Telecommunications, P.O. Box 2794, 1111 Country Club Road, Middletown, CT 06457-9294, 203-685-8031.



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Readers' choice

Of all the new products and services in the October 1994 issue, the one reprinted here generated the most reader requests for additional information. If you missed it the first time, here is your opportunity to acquire more information on it. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Hand-held radio receiver employs extremely wide frequency range



The wide-range, hand-held Trident TR2400 radio receiver from Ace Communications covers virtually all voice broadcast frequencies, from 100kHz to 2.06GHz. Its demodulation modes are AM for broadcast, worldband and for civil and military aviation; narrowband FM for police, fire and emergency transmissions; wideband FM for radio and TV audio broadcasts; and single sideband for transoceanic aircraft and ships at sea. Desired frequencies are entered on a keypad, and entries are displayed on a backlit LCD. The unit searches for active channels and allows the user to store as many as 1,000 locations in permanent memory. Power is supplied by four AA batteries. Audio is heard through the built-in speaker or the supplied earphone. Other accessories include a 12Vdc dashboard plug, ac battery charger, belt clip, flexible antenna and mounting hardware.

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Cellular test amplifier raises monitor output power levels



A portable cellular test amplifier designed to raise signal generator and/or spectrum monitor outputs to communications power levels is available from VoCom Products. Two models will amplify signal generator outputs (220dBm to 0dBm) to 15W and 50W. Full power adjustment is provided, making the units suitable for 3W-6W signal level testing and field-strength calibration. Full cellular band coverage provides an economical alternative to wideband high-gain amplifiers. Other models are available for other communications bands.

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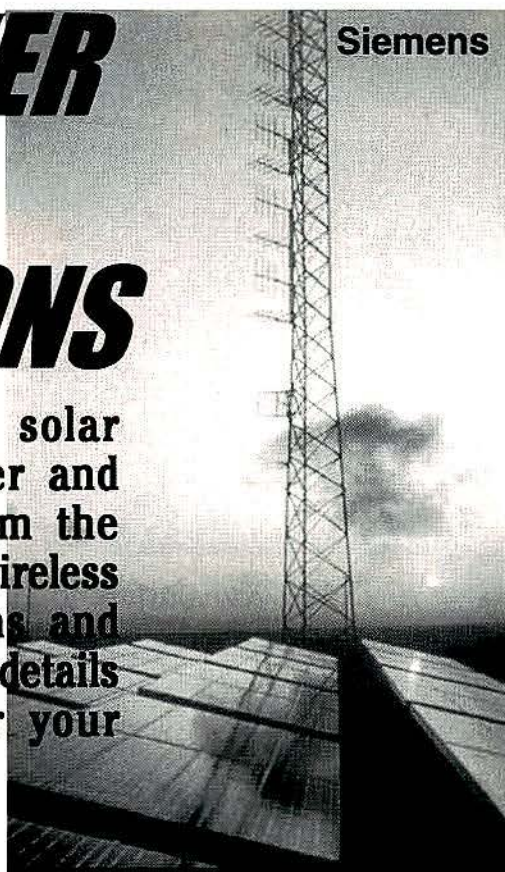
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Siemens high-efficiency solar modules - exceptional power and proven reliability make them the leading choice for supplying wireless power to telecommunications and RF installations. For complete details on how Hutton can power your system, call today!



Circle (49) on Fast Fact Card

New products

Software system walks users through Form 600 applications step-by-step

Brown and Schwaninger has created the *Form 600 Made Painless* software system that enables users to complete and print any applications that use FCC Form 600. The software automatically converts feet to meters, or miles to kilometers, and assists in converting NAD 27 geographic data to NAD 83. The software also auto-

matically fills in many of the questions consistent with the type of application being filed. Users may print a report that will identify possible missing or incorrect entries in their application. The printed product is your application to the FCC and can be stored on disk for future use.

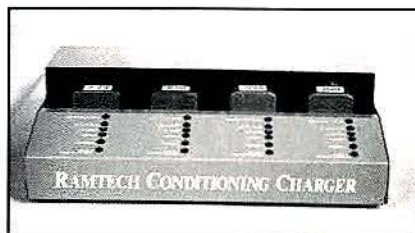
Circle (402) on Fast Fact Card



Decoder assists setup, management for advanced messaging paging

The Signalpro decoder from Advanced Signal assists paging system operators in the setup and maintenance of advanced messaging paging systems and ensures maximum channel utilization. Signalpro was specifically designed to decode Motorola's Flex paging protocol in addition to standard numeric paging formats. Used in conjunction with a paging channel receiver and a PC, the unit decodes the paging formats, and the PC transforms the paging data into useful information. A graphical user interface (GUI) operates in conjunction with Windows 3.1 or higher to provide a point-and-click menu interface for manipulating display windows, file storage and parameter changes.

Circle (403) on Fast Fact Card

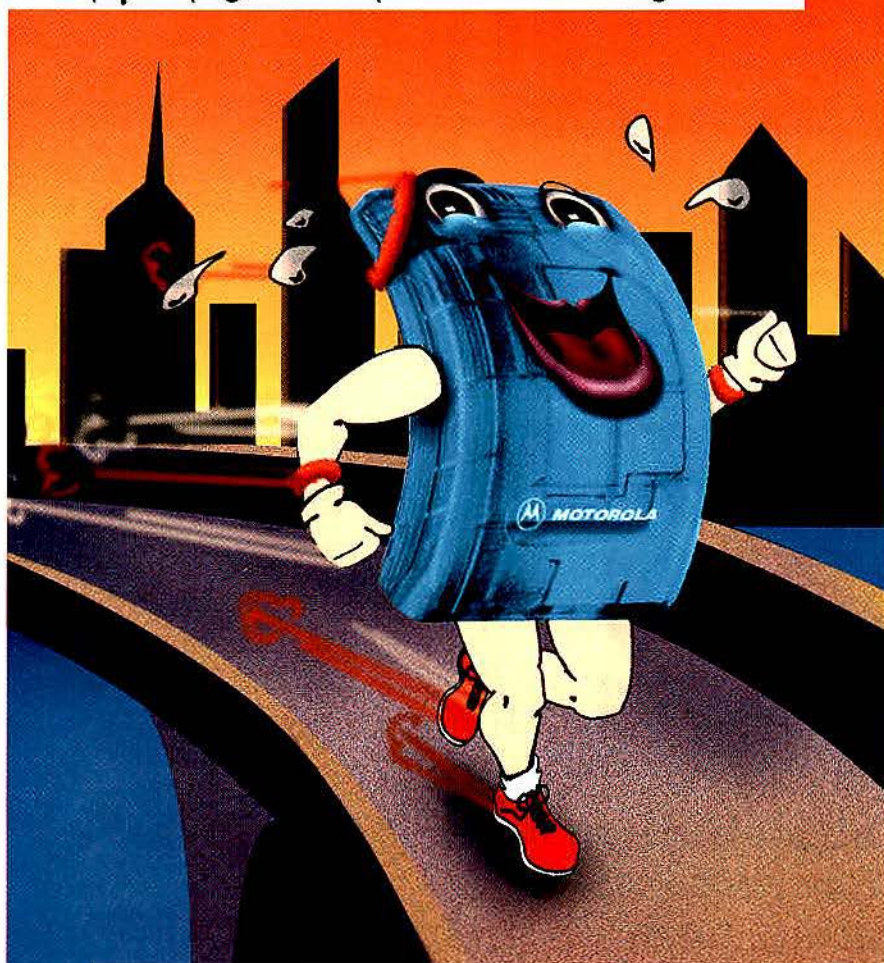


Battery support station combines fast charger, analyzer, conditioner

The Ramtech conditioning charger from BatteryPro Centres combines a fast charger, analyzer and battery conditioner in one unit. Each battery-specific adapter is equipped with an optical sensor that will start a self-test on the specific controller card when a battery is inserted. Batteries are processed simultaneously in multicharger models. Batteries left unattended in the charger are cycled weekly to prevent degradation. Capacity testing is performed every tenth time a battery is inserted in a specific charger. Other features include autonomous adapter operation and battery temperature monitoring.

Circle (404) on Fast Fact Card

Keep your pagers in shape with Motorola Pager Care.™



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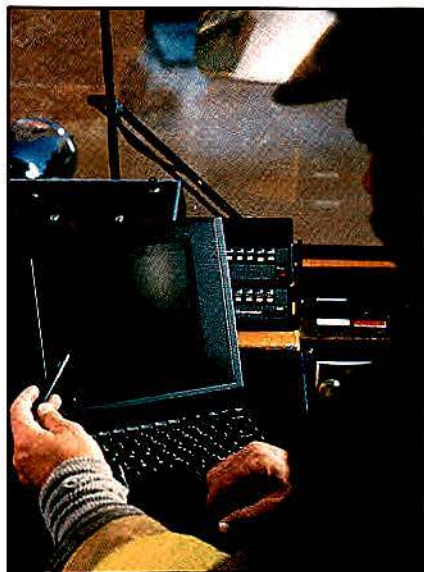
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Circle (50) on Fast Fact Card

Software provides firefighters location information en route



WaveSoft-Fire from Motorola's RadioWare Software Solutions is a software package for emergency response firefighting applications. Used in conjunction with an in-vehicle computer, the software uses an RF link to access both text and graphics information on a location while the response vehicle is en route. A dispatch link module allows wireless RF transmission of response strategy and mapping information. The program is designed to supply firefighters with access to site-related information such as building pre-incident surveys, hazmat background, mapping of addresses and hydrant and gas line locations.

Circle (405) on Fast Fact Card

Dehydrator provides pressurization for small-volume transmission lines



The DryLine MT-050 series dehydrator from Andrew provides pressurization for small-volume (0 to 10 cubic feet) transmission lines. Applications include cellular, broadcast, microwave and earth station antenna systems. The MT-050 is fully automatic and does not require bypass kits, ancillary air tanks or heaters.

Circle (406) on Fast Fact Card

Mobile unit transmits cardiac telemetry to receiving hospital



The Life-Tel T.S.S. (telemetry sending system) from Racom Products is designed

for mobile emergency medical applications. The unit transmits ECG strips to the receiving hospital via mobile radio, cellular phone or landline telephone. Internal AA batteries are monitored by an LED low battery indicator. The unit also can be used with a 12Vdc power source or an ac adapter. A receiving console, the Life-Tel T.R.S., is also available.

Circle (407) on Fast Fact Card

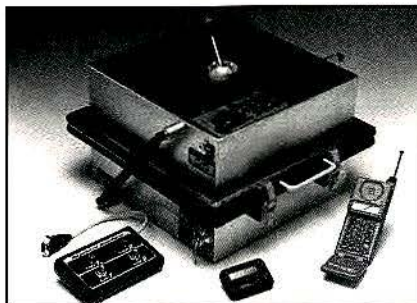
MAS radio series incorporates calibration and control features

Alligator Communications has added automatic calibration and control features to its 900MHz multiple address system (MAS) radios. New features include: Automatic Global Frequency Calibration (AGFC); automatic deviation control; and automatic level control. The master unit is fully redundant and incorporates hot/warm standby with automatic transmitter A/B cycling.



Circle (408) on Fast Fact Card

Isolation test chamber provides interference-free environment

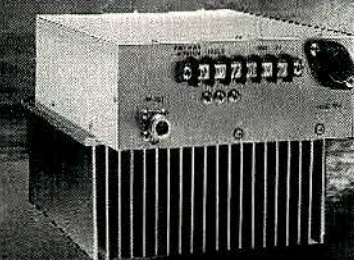


The Isolator 144 RF isolation test chamber from Tripplett provides an interference-free test environment for two-way radios, pagers or cellular phones. Typical RF isolation is 80dB. The unit also approximates free space, preventing reflections and loading of the antenna. Baseband and power connections are also provided. A joy stick manipulator for button testing covers an area nearly eight inches in diameter.

Circle (409) on Fast Fact Card



Power Amplifiers Base & Repeater



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Circle (51) on Fast Fact Card

Product/Logo directory

For more information on the products and services offered by the following advertisers in this issue, circle the corresponding number on the Fast Fact Card found on page 81.

Andrew Corporation

Andrew Corporation is an international supplier of communications equipment and services. Andrew offers coaxial cable, connectors and accessories for wireless communications applications.



Circle (451) on Reply Card

Celwave

Celwave manufactures a wide array of communication system components: base station, mobile and portable antennas; cavities; fillers; duplexers; receiver multicouplers; combining products; amplifier systems including BDA systems; and transmission line products.



Circle (452) on Fast Fact Card

Centurion International

Antennas and batteries for mobile communications. LMR, cellular, PCN, PCS, PCMCIA and other wireless applications. Engineering and Design department available to assist with custom antennas and/or batteries.



Circle (453) on Fast Fact Card

Combined Technologies

Combined Technologies manufactures remote display and control equipment for receiver voting systems. It also makes transmitter steering controllers that work with comparators (voters) to steer multiple transmitters.

Circle (454) on Fast Fact Card

Communications Specialists

Tone signaling equipment for two-way radio systems, including paging encoders/decoders, repeater tone panels, DTMF, CTCSS, DCS retrofit devices, Morse station IDers and video transmission equipment.



Circle (455) on Fast Fact Card

Connect Systems

Connect Systems' model CS-900 vox-controlled, simplex interconnect eliminates costly leased lines and dc remotes. Access your base radio from any telephone, anywhere.

Circle (456) on Fast Fact Card

Decibel Products

Decibel Products, a division of the Allen Telecom Group, designs, engineers and manufactures base station equipment solutions for virtually all RF standards applications, including cellular/GSM, PCS, AMPS, NAMPS, TACS, ETACS and SMR.

Circle (457) on Fast Fact Card



Doppler Systems

Doppler Systems offers a line of reasonably priced direction-finding systems covering 50MHz-1,000MHz. Users include cellular companies, two-way commercial radio networks and government agencies.

Circle (458) on Fast Fact Card

Hutton Communications

Wireless communications equipment and components are available from Hutton. As a regional distributor with national strength, Hutton can offer fast delivery, personal service and product delivery.

Circle (459) on Fast Fact Card

IFR Systems

IFR Systems designs, manufactures and markets communications service monitors, RF and microwave spectrum analyzers and avionics test equipment. Through its wholly owned subsidiary, Photon Kinetics, the company also provides test equipment for the manufacture, installation and maintenance of fiber-optic systems.



Circle (460) on Fast Fact Card

Maxon America

FM two-way communications equipment offered by Maxon includes synthesized VHF and UHF portable and mobile radios and crystal portable radios for VHF lowband, VHF highband and UHF. POCSAG numeric pagers, paging systems, data telemetry modules and SMR/trunking products.



Circle (461) on Fast Fact Card

Midian Electronics

Three new feature-packed Midian products available for the Radius GP-300/P110: 1) High-security scrambler w/OTAR; 2) Radio-telephone/trunking w/10 operating zones, multivendor-compatible, scrambler, plus many other features; 3) Multi-format universal encoder/decoder w/ANI, ENI, transpond, scrambler.



Circle (462) on Fast Fact Card

Modular Communication Systems

Ultra-Com PRO microprocessor-based communications control system. Features include proprietary "Screenmaker" and "Customizer" programs, enabling user to design screens and operating parameters for specific systems and operating procedures.

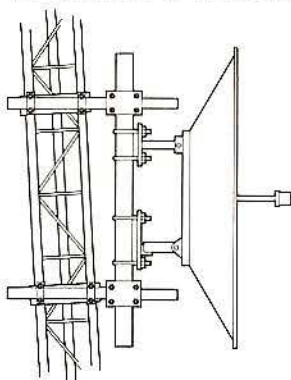
Circle (463) on Fast Fact Card

PanaVise

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Circle (464) on Fast Fact Card

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Circle (52) on Fast Fact Card

PiRod

PiRod's "Tower Parts and Accessories" catalog is loaded with photos, drawings and descriptions to help you identify, specify and price the tower parts you need.

Circle (465) on Fast Fact Card

PolyPhaser

PolyPhaser Uni-Kit 2 kits ground copper to copper, copper to tin, tin to tin, and tin to copper. Kits fit cables from 1/4" to 2" diameter and ellipticals up to EW28.

Circle (466) on Fast Fact Card

Silicon Valley Power Amplifiers

Recognized for its excellent service and quick responsiveness, Silicon Valley Power Amplifiers unites the best of RF technology with stringent manufacturing standards to provide a range of high-quality CW rated power amplifiers.

Circle (467) on Fast Fact Card

TPL Communications

The LMS series power amplifier is a fully enclosed package. It includes power supply, metering, SWR and overtemp protection. Power levels to 120W, 35MHz-960MHz.

Circle (468) on Fast Fact Card

Transcrypt International

The DME 9600 dual-mode encryptor provides both digital encryption and analog voice privacy over the public switched telephone network (PSTN). The unit is backward compatible with Transcrypt's analog cellular and landline voice privacy products. The DME 9600 plugs between the handset and base unit of any office phone, preserving proprietary features and functions.

Circle (469) on Fast Fact Card



Trilogy Communications

Trilogy Communications is a major supplier of coaxial cable for the worldwide CATV and telecommunications markets. The AirCell product line, by Trilogy, including the Air-dielectric Radiating Cable, features fully bonded, hermetically sealed chambers requiring no pressurization. ISO-9001 registered.

Circle (470) on Fast Fact Card



Wavetek

The 4032 Stabilock supports all of the known digital cellular formats. It will test TDMA, GSM, JDC at 800MHz and 1.5GHz mobiles and base, CDMA mobiles and base and CS-1800 at 1.8GHz.

Circle (471) on Fast Fact Card



Zetron

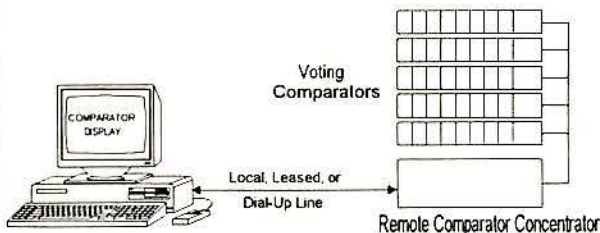
Beauty and the Best. As many as 25 remotes can control a single LTR base station over any voice-grade, two-wire line. Compatible with EFJ 8600 or Challenger Plus remote-mount radios, also compatible with Kenwood TK 930, 931 and HD radios.

Circle (472) on Fast Fact Card



Refer to the Advertisers Index on page 80 for the page reference to the company's advertisement

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Circle (53) on Fast Fact Card

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Circle (54) on Fast Fact Card

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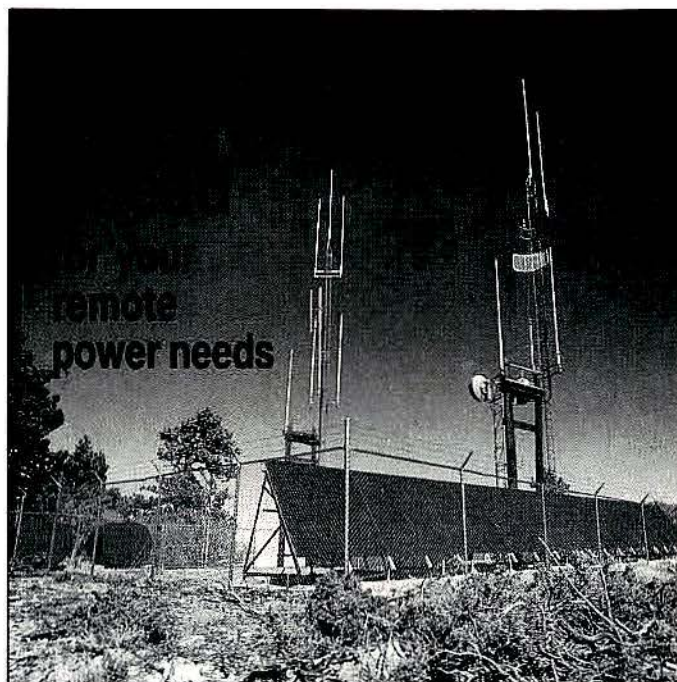


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Circle (56) on Fast Fact Card

Literature

Selection Guide contains more than 1,000 products

A 320-page product selection guide features all of Celwave's 1,000+ products, which include base station antennas, filters, transmitter combiners, bi-directional amplifiers, duplexers and receiver multicouplers. Users will find each product family accompanied by photos and/or illustrations, specifications, ordering information, features and benefits, and, where appropriate, graphics illustrating performance characteristics.

Circle (301) on Fast Fact Card

Catalog describes audio accessories

A color catalog describes audio accessories for productive communications in hostile environments. The catalog from Ear-mark is divided into sections that include Loudmouth products, headphones, microphones, service and warranty information.

Circle (302) on Fast Fact Card

Catalog covers solar accessories

A solar catalog from Hutton Communications is designed to make ordering easier. As well as information on power systems and solar accessories, the catalog offers specific application systems with worksheets and photos. The company's power systems team is available to aid in the custom design of systems for interested customers.

Circle (303) on Fast Fact Card

Selection guide lists test equipment

A 16-page color wireless communications selection guide features information on Wavetek's range of test equipment. It includes information on the Stabilock 4032, which tests as many as 40 formats for analog/digital cellular, mobile radio and paging markets. Also highlighted are the 3600D cellular test set and the 600 CAT cellular activation test set, as well as paging equipment and service monitors.

Circle (304) on Fast Fact Card

Catalog includes planning guides, technical data

A 620-page color catalog from Andrew has major sections on microwave systems; broadcast and satellite earth station antenna systems; coaxial cable, connectors and accessories; waveguide; towers and equipment shelters. Other sections include distributed communications services antennas for tunnels and buildings and special application antennas. The catalog contains detailed descriptions, specifications and photographs of products, plus planning guides, technical data and tips on how to troubleshoot a system or product problem.

Circle (305) on Fast Fact Card

Catalog describes racks, rack accessories

A 24-page catalog describes Middle Atlantic Products' line of racks and rack accessories, including shelves; panels; vents; cooling; and rails and hardware. Each listing contains a description and a list of features, specifications and illustrations.

Circle (306) on Fast Fact Card

Catalog covers power products

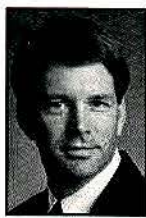
A 66-page power products catalog from Hewlett-Packard is targeted toward research and development and production engineers. It contains the latest technical information on alternate-current sources, direct-current power supplies and electronic loads, power-test systems and solar-array simulators for the lab or factory.

Circle (307) on Fast Fact Card





Albert J. Flynn



Tim Pittman



Thomas McCuin



James Heath

Changes at Seiko Communications, Beaverton, OR:

Albert J. Flynn III, senior vice president of marketing and sales, advances to president of Seiko Communications of America.

Kenneth Gray, vice president of engineering, moves up to president of Seiko Communications Systems.

Tim Pittman leaves United States Cellular, Chicago, as market manager to join Everon America, Jackson, MS, as director of sales and marketing for the North American and Latin American markets.

Changes at Midland International, Kansas City, MO:

Thomas P. McCuin departs Argus Systems as a regional manager to join Midland as an area manager based in Raleigh, NC.

James A. Heath, area sales manager based in Minneapolis, advances to bid-and-quote manager.

Jerry Stupka, managing director of international sales and marketing for Allen Telecom Group, Cleveland, advances to vice president of international sales and marketing.

Changes at Stanilite Pacific, Annapolis, MD:

James Crinklaw leaves E.F. Johnson, Burnsville, MN, as area manager of advanced systems to join Stanilite as sales manager for North America digital mobile products.

Thom Morrow exits Motorola LMPS as sales manager in Tampa, FL, to become vice president of North American Operations for Stanilite.

Changes at Communications Associates, Joliet, IL:

Sara Anderson leaves the sales staff of Mobile Communications, Bourbonnais, IL, to join Communications Associates as product manager.

Lori Alexa departs Ryerson Steel, Chicago, as a member of the sales staff to become marketing director for Communications Associates.

Changes at Transcript International, Lincoln, NE:

Gerard Donovan exits Becton-Dickinson, Holdrege, NE, as senior quality assurance engineer to join Transcript as quality assurance manager.

Max Neighbors, senior accountant for Nebraska Furniture Mart, Omaha, NE, becomes assistant controller at Transcript.

Promotions at Digital Microwave, San Jose, CA:

Graham Powell, sector vice president for sales in Europe, Africa and the Middle East, moves up to vice president of worldwide sales.

Shaun McFall, director of marketing, advances to vice president of corporate marketing.

Tim Hansen, vice president and program manager, moves up to vice president of the Spectrum business unit.

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Circle (57) on Fast Fact Card

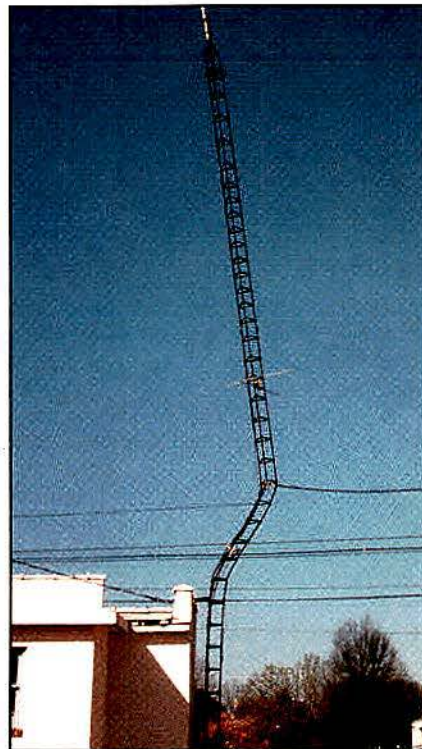
L etters from readers

Tower for 'offset' frequencies:

Here are photographs of a radio tower in Flemington, NJ, that was damaged in an unusual way. A concrete truck caught a guy wire to the tower owned by Flemington Block & Supply and pulled it just enough, forming an offset.

Being in the industry for 30 years, right away I thought of using this tower for the "offset" frequencies.

Charles F. Adams
President
Industrial Communications
Easton, PA



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Circle (59) on Fast Fact Card

Mobile Radio Technology™

The journal of mobile communications technology

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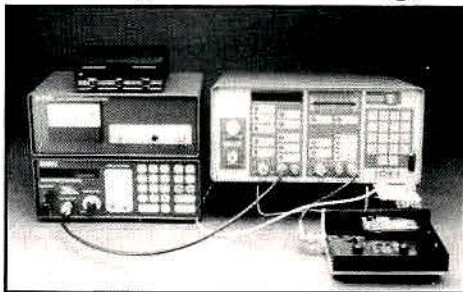
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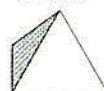
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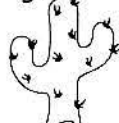
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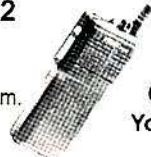
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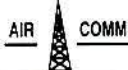
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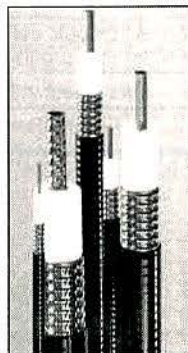
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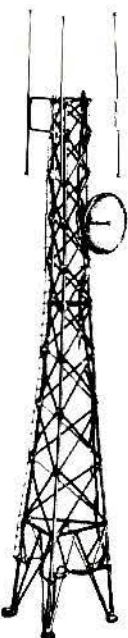
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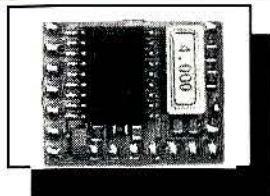
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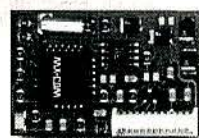
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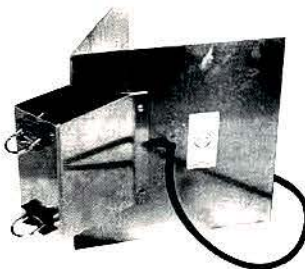
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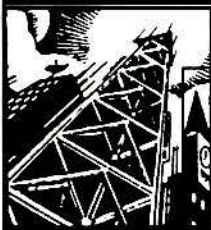
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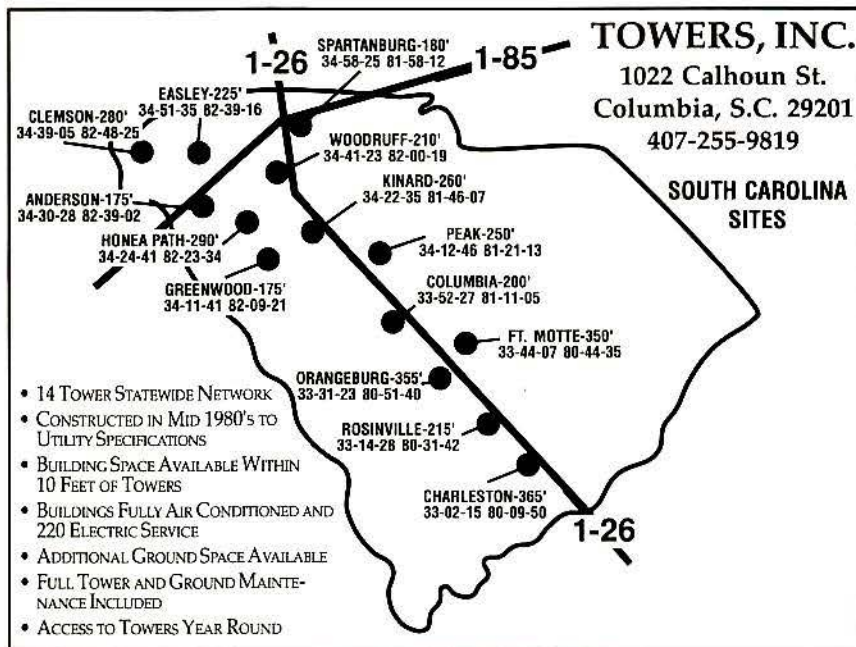


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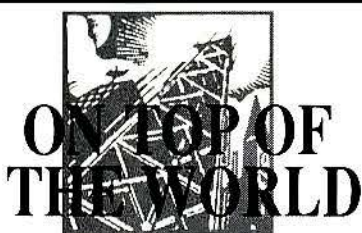
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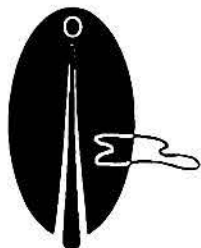
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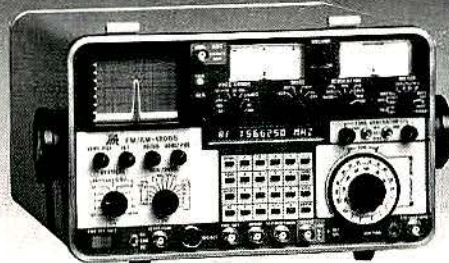
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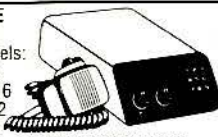
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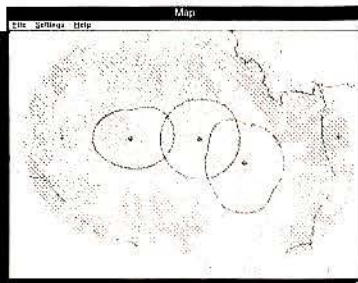
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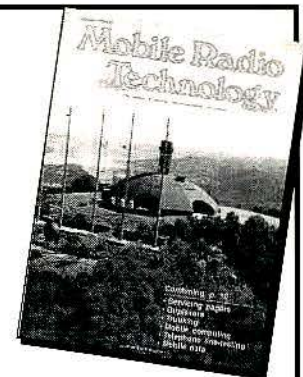


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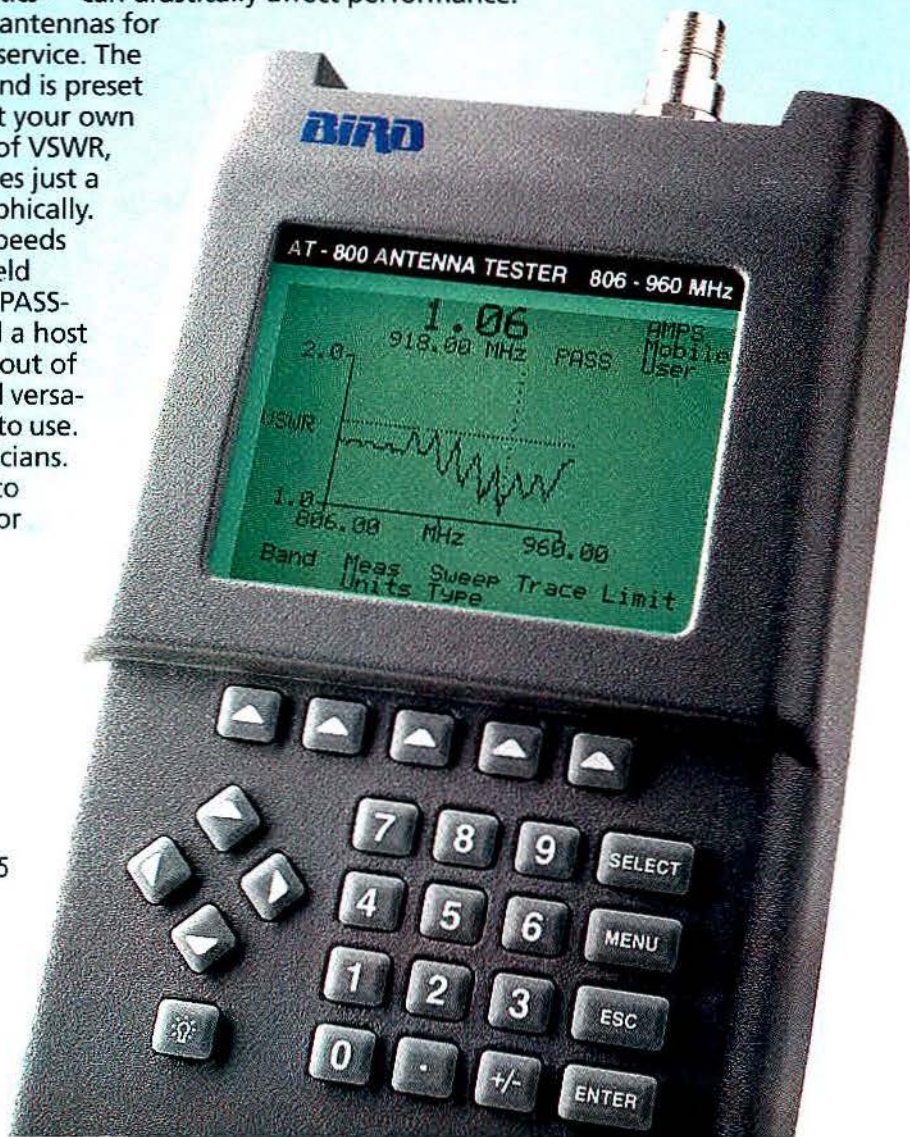
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Two-tone Sequential Encoder. Sub-assembly mounts inside radio or other enclosure. Multiple call capability. 1.25" x 2.0" x .4"



SD-1000 **\$59.95**

Two-tone Sequential Decoder. Programmable unit provides switched outputs from two-tone paging calls. 1.25" x 2.0" x .4"



DTD-1 **\$59.95**

Single Function DTMF Decoder. Provides switch outputs via DTMF. 1.25" x 2.0" x .4"



PE-4/PE-15 **\$99.95**

Multiple Call POCSAG (RPC-1) Paging Encoders. Where direct control of local area paging is desired. 1.78" x 1.03" x .35"



DCS-23 **\$59.95**

Digital Coded Squelch Encoder-Decoder. Programmable to all codes. 1.36" x 1.18" x .25"



TS-32P **\$57.95**

Programmable CTCSS Encoder-Decoder. Tone squelch for any FM transceiver. 1.25" x 2.0" x .4"



TS-64 **\$64.95**

Sub-miniature Programmable CTCSS Encoder-Decoder. 1.7" x .78" x .25"



SS-32SMP **\$27.95**

Sub-miniature CTCSS Encoder. Jumper programmable. .53" x 1.0" x .16"



SS-32PA **\$28.95**

Programmable CTCSS Encoder. Custom tones or audible tones also available. .9" x 1.3" x .4"

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